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The Development of Electronic Book Contained Scientific Literacy in Learning Physics to Enhance Students' Academic Achievement

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Abstract. Technology-based teaching materials enriched with scientific literacy are not yet available, notably regarding the topic of Newton's law of gravity. This study aims to develop e-booster and describe its validity, practicality, and effectiveness. This study uses ADDIE development model with the research subjects consisting of 38 students of X MIPA at a public high school in Banjarmasin. The data collection technique is implemented through interview, observation, questionnaires, and tests. The data analysis is carried out by examining the percentages of the validity test, the average scores obtained from the survey results, as well as the results of the N-gain test and t-test on students' academic achievements. The results indicated that: (1) the validity test result of e-booster obtained 88.71% which was categorized as very high (2) the practicality result of e-booster obtained 75.39% which was categorized as practical, and (3) the effectiveness of e-booster in improving student's learning achievement obtained 0.57 which was categorized as moderate and significant at the level $\alpha=0.05$. It is then concluded that e-booster is valid, practical, and effective, and thus, suitable to be integrated within learning physics to enhance students' academic achievement.

Keywords: E-booster, electronic book, scientific literacy, physics learning.

Introduction

The advancements of 21st-century technology has become a new paradigm for human beings and has had a significant influence on various sectors in life, specifically on education (Benešová & Tupa, 2017). The presence of technology is expected to play the role as a powerful, intellectual tool in education, particularly in supporting the construction of one's knowledge. Accordingly, the integration of adaptive technology can elevate the quality of education (Huda, et al., 2018). Adaptive technology, in this case, refers to the use of mobile computing devices such as smartphones, tablets, and e-readers in the teaching and learning process (Grant, 2019). Internet-based learning, such as mobile learning, can provide endless, diverse multimedia contents which promote feasibility in the interactions between teachers and students. Features in mobile learning, for instance, audio, video, and audiovisual ones, are new alternatives used for delivering teaching materials and concepts which are difficult to contextualize. Likewise, the majority of the concepts taught in physics education is still difficult to visualize nowadays (Anshari, et al., 2017).

In order to encounter the challenges of the 21st century, students need to be equipped with skills qualified enough to show their competitiveness in the globalization era. The integration of 21st-century skills which consist of digital literacy, inventive thinking, effective communication, and high productivity becomes crucial in education. One of the subdomains needed to support these four domains is scientific literacy (Ariesteidou & Christothea, 2020; Turiman, et al., 2012). Scientific literacy plays an important role in broadening learners' knowledge, investigation of natural science, as well as oral and written vocabulary needed to understand science, the relationship between science, technology, and society (Hernandez, et al., 2015).

Up to this point, many studies related to mobile learning have been carried out, many of which implemented mobile phone applications such as Tong (Tong, 2016), Jeger (Sulistyo & Kurniawan, 2020), and Projo Bale (Sayono, et al., 2020). However, the above-mentioned platforms are only accessible for Android device users, thus excluding non-android device users. In addition, various research related to scientific literacy within several science subjects' learning process had been carried out, such as biology (Wei & Xia, 2016), chemistry (Seftari, et al., 2018), and physics (Rusilowati, et al., 2016), all of which integrated scientific literacy within the textbooks, forcing the whole "offline" learning method for these subjects. This is contradictory to the fact that our education system must follow the advances made in the modern era and integrate latest technology and digital contents within learning and teaching, such as using more multimedia resources in presentations and the use of digital materials within the learning process (Grynyuk, et al., 2022; Engbrecht, 2018).

Focusing in the teaching of physics, there is no research found related to scientific literacy integrated with technology which discusses Newton's law of gravity. This is unfortunate as it contains a lot of scientific literacy indicators as described by Wilkinson (Wilkinson, 1999) which include: (a) science as a body of knowledge, (b) science as a way of investigating (c) science as a way of thinking, and (d) the interaction between science, technology, and society. Serving the role as "basic knowledge and skills" required in each individual (Turgut, 2007), scientific literacy can be considered as a new demand in promoting education in terms of sustainability throughout students' future career and academic achievements (Correia, et al., 2010). Scientific literacy in Newton's law of gravity does not only involve basic concepts, but also the scientific theories and hypotheses substance, as well as understanding for problems and problem solving that calls for a scientific investigation. Scientific literacy is important as it provides context to overcome social problems (Mourtzis, et al., 2022). A scientifically literate generation can solve these problems better, make well-thought decisions that will affect the individuals' quality lives, and become lifelong learners (Zen, 1990). Therefore, the process of acquiring knowledge through scientific literacy places more emphasis on the skills integrated within the indicators. These skills are important for students, especially regarding problem-solving and decision making (Gucluer & Kesercioglu, 2012).

Although numerous studies have examined the enhancements on students' academic achievement through several innovations, namely literacy (O'Toole & Kannass, 2018; See & Gorard, 2020), scientific literacy (Wen, et al., 2020), mobile learning through laptops enriched with literacy content (Bando, et al., 2017), mobile learning through tablets enriched with literacy content (Mang, et al., 2017), and mobile learning through electronic books enriched with literacy content (Ihmeideh, 2014), but so far there is no research on mobile learning using electronic books enriched with scientific literacy content. Therefore, this research is carried out to enhance mobile learning by developing e-booster (electronic books contained scientific literacy) with the topic of Newton's law of gravity, accessible through various types of online-based computers and smartphones. This study aims to develop e-booster and describe its validity, practicality, and effectiveness.

Methods

This research uses research and development (R&D) method with ADDIE model which consists of analysis, design, development, implementation, and evaluation (Branch, 2009). The steps carried out are executed as follows: the analysis stage is carried out to investigate the problems and solutions; the design stage is carried out by designing e-booster; the development stage is done by increasing the accessibility of e-booster; the implementation stage is implemented by testing e-booster on 38 students of X MIPA, and the evaluation stage is carried out by correcting or revising e-booster if deemed necessary. The details of these steps are described in Table 1.

Table 1. Details of product development stages using ADDIE model

Step	Activity	Result
Analyze	Analyzing the problems found in the research subject's class.	Physics books used are monotonous and rigid, not proven to have enhanced learners' knowledge, curiosity of natural science, oral and written vocabulary. 63% of the students are Android users whereas 37% of students are iPhone users.
	Analyzing on the standard competencies and basic competencies	The planets' motion in the solar system based on Newton's laws is analyzed.
	Analyzing the characteristics of the materials taught in Newton's law of gravity	Sub-materials are placed in order of the meetings taught. The force of gravity is delivered in the first meeting, followed by the strengths of gravitational field in the second meeting, as well as Kepler's Laws and satellite motion.
	Analyzing on students' characteristics	Students actively ask questions, tend to have high level of curiosity, and promote positive learning competitions with each other.
	Analyzing on possible resources that indicate problem-solving.	A trial is conducted to produce electronic books on various mobile applications or computer software. Based on the trial, it is decided that electronic book using professional flip PDF application is chosen, so it can be accessed online.
Design	Creating books using Microsoft Word	The cover, layouts, templates, color combinations, font types, and font sizes are determined.
	Adding designed concepts using Flip PDF Professional software	Some features, such as links, videos, GIFs, hyperlinks are created, as well as making the final evaluation exam (multiple choice questions). File extension is formatted as HTML.
Development	Integrating contents with supporting media to make it accessible in any smartphone device	Hosting to website. Validity data is also performed by the validator and given suggestions for improvements.
Implementation	Implementing the treatment of e-booster on 38 students	This treatment was given for two meetings.
Evaluation	Giving Formative and summative evaluation	E-booster's effectiveness and results are evaluated, revisions are also conducted if necessary

E-booster's quality is indicated by its validity, practicality, and effectiveness. Validity refers to product testing, similar to formative evaluation, used to produce a product that conforms to a predetermined specification plan through the identification of the product's strengths and weaknesses during the process (Rusdi, 2018). In this study, e-booster validity was tested by three validators and determined by the criteria in Table 2 (Akbar, 2016). E-booster is considered as valid if the category reached is at least medium.

Table 2. E-booster validity criteria

No.	Percentage of Validity	Category
1	80.01 - 100.00	Very high
2	60.01 - 80.00	High
3	40.01 - 60.00	Medium
4	20.01 - 40.00	Low
5	01.00 - 20.00	Very low

The practicality of E-booster is to measure the convenience of E-booster which is carried out by distributing questionnaires for the students (Aminah, 2016). In this research, the practicality e-booster is determined based on the criteria in Table 3 (Akbar, 2016). E-booster is considered as practical if the category reached is at least sufficient.

Table 3. E-booster practicality criteria

No.	Average Score	Category
1	80.01 - 100.00	Very practical
2	60.01 - 80.00	Practical
3	40.01 - 60.00	Sufficient
4	20.01 - 40.00	Less practical
5	01.00 - 20.00	Very impractical

Effectiveness refers to the achievement of predetermined goals (Rohmawati, 2015). The effectiveness of e-booster is determined based on the criteria in Table 4 (Hake, 1998). E-booster is considered effective if the category reached is at least medium.

Table 4. E-booster effectiveness criteria

No.	Gain Score	Category
1.	$(\langle g \rangle) \geq 0.7$	High
2.	$0.7 > (\langle g \rangle) \geq 0.3$	Medium
3.	$(\langle g \rangle) < 0.3$	Low

To determine the significant effect of e-booster in improving students' academic achievement, t-test was carried out. The data obtained from the results of the pre-test and post-test which are normally distributed meet the requirements of the t-test with the hypothesis that there is an effect of using e-booster in learning physics in improving students' academic achievement if the t value is > t table (Sarwono, 2015).

Results and Discussion

Internet of things become a modern educational orientation as it can easily be accessed by everyone (Kurniawan, et al., 2019). Learning using the internet becomes the reason why e-booster is designed online, to make it accessible by all device users, be it computers, iPads, iPhones, or Androids for free. There is no time limit nor working hours on e-booster. The following figures present the displays of the products being developed.

The development of e-booster becomes a reference and alternative to improve students' learning experience, specifically on Newton's Law of gravity which is closely related to the scientific literacy indicators. The components in e-booster include:

a. Learning activities are designed according to students' needs. Digital books are accessed just like using textbooks in general; students turn each page of the book accompanied by the audio file respectively. The availability of material exposure is supported with colorful images, moving animation, and educational videos, complete with sample questions to help the process of integrating materials being taught, practice questions to increase students' understandings about the concepts, and answer keys for self-assessment.

Figure 1. The Developed E-Booster

b. Scientific literacy content is presented through the four indicators, namely science as a body of knowledge, science as a way of investigating, science as a way of thinking, and the interaction between science, technology, as well as society that is presented as accordingly with the subtopics taught.

Figure 2. Science as a body of knowledge (presenting theory)

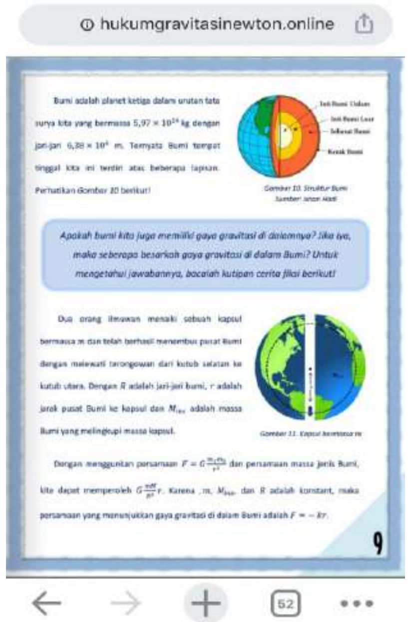

Figure 3. Science as a way to investigate (explaining the answer)

Figure 4. Science as a way of thinking (causal relationship)

Figure 5. The interaction of science, technology, and society (future career)

Validity test results

Based on the assessment obtained from validator, the e-booster validity results obtained an average score of 88.71, which was categorized as very high. These results were obtained from 3 validity indicators covering content validity, appearance validity, and scientific literacy validity. Content validity indicator received an assessment of 85.56 and the validator gave suggestions to provide subtitles on the educational videos to ease students in understanding the information and knowledge delivered. Improvements and revisions were made by adding Indonesian subtitles to all educational videos in e-booster.

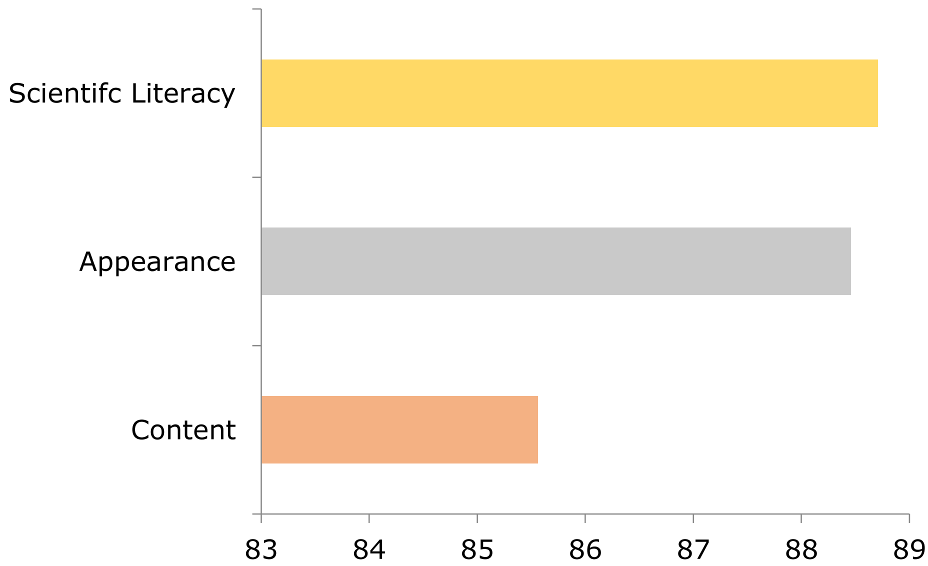

Figure 6. E-booster Validity Test

The reason behind e-booster being accessed through a website page is to avoid cache overload and storage usage that can cause troubles due to the large RAM usage and smartphone memory capacity (Kim, et al., 2012). The materials in this electronic book is arranged systematically to make it easier to convey the desired materials to students (Ivey, 2010). E-booster uses communicative language and there are foreign terms used such as goldilocks, the pale blue dot, and retrograde that play a very important role in students' literacy development (Lee, et al., 2019).

Color selection is also important concerning cognition and students' behavior (Sa'aleek, 2018). E-booster is dominated with the colour of Lazuardi (sky blue) because it can stimulate learners' motivation, creativity, and imagination (Mehta & Zhu, 2009). E-booster uses two types of fonts which belonged to the sans serif group, namely calibri (body) and just another hand. These fonts are selected to adjust with students' readability when displayed on either a computer screen or a smartphone screen (Hojjati & Muniandy, 2014). The use of images in E-booster are also intended to increase students' motivation and imagination to study on the text presented. Most of the pictures are presented in the form of illustrations to gain students' attention and encourage more detailed, textual data processing, as well as help creating non-verbal codes with the purpose to ease students in comprehending the materials (Kasmaienezhadfard, et al., 2015).

E-booster emphasizes reading activities as the strategy to improve scientific literacy in the classroom (Grant, et al., 2015). Reading activities will direct students to engage in thinking activities. Through thinking activities, not only will they be triggered with a high curiosity level towards nature, but also to carefully make calculations and find answers to their curiosity. Other than the materials presented, Matthews stated that reading activities which are given through science history are aimed to develop students' reasoning and thinking skills, as well as fostering their interest in science and humanitarian attitudes (Cansiz & Universitesi, 2017). Therefore, the identification of topics in the learning process must be relevant (Grant, et al., 2015) and meaningful in life as to increase students' motivation to learn.

Practicality test results

Based on the assessment obtained from the 38 students, the practicality of e-booster obtained an average score of 75.39% and was categorized as practical. These results were obtained from the three practicality indicators, namely benefits, efficiency, and convenience.

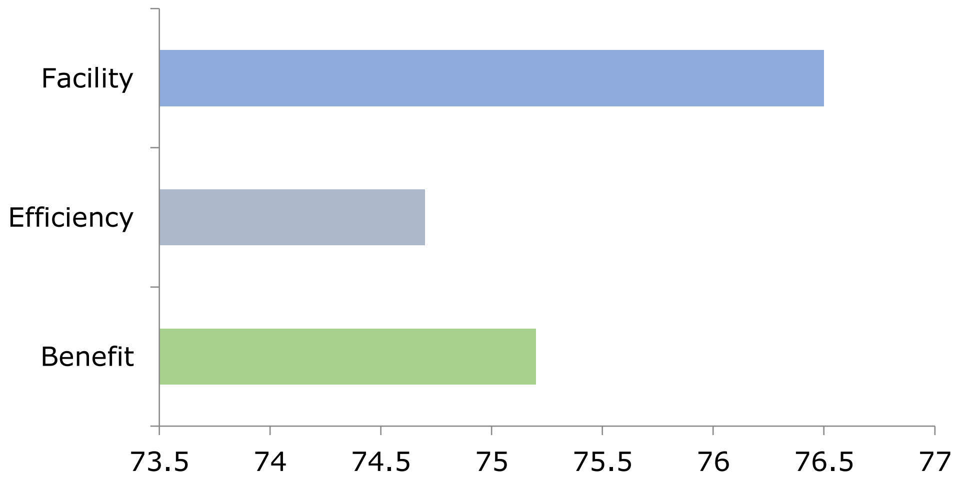

Figure 7. E-booster Practicality Test

The convenience criterion tested on e-booster emphasizes on how much effort is spent in the usage of e-booster. Meanwhile, the efficiency criterion relates to the use of cellular data and resources (device battery), and the benefit criterion relates to the feedback received from students during and after using e-booster. One of the indicators on the benefit criterion is related to knowledge and information received. E-booster enabled 92% of students acquire new knowledge and information, such as goldilocks, geocentric, heliocentric, light years, and retrograde. The new knowledge and information obtained showed a significant impact on students' interest in studying astronomy in 77%, followed by students' interest in pursuing career in science and technology, which increased by 58%. E-booster adheres to multimedia learning cognitive theory, which suggests to provide educational videos and moving animations to ease the integration of new information into cognitive structures, which can improve learning process (Brame, 2016). The increase in learning process, according to the multimedia learning cognitive theory, has an impact on student's convenience to understand the material. Students' convenience in comprehending the material also depends on classroom conditions and circumstances.

E-booster presents the history of science and scientists, as well as an analysis of countries with the latest technology and good economic prosperity. This topic opens up numerous discussions between teachers and students, thus building a good learning within the environment. A conducive environment plays an important role in building the participation and activeness of students in the classroom (Susak, 2016), with the hope that it can encourage students' participation through discussions related to scientific literacy and economic welfare (Ogunkola, 2014). This was also admitted by 92% of students who stated that learning physics using e-booster promotes a positive and enjoyable learning atmosphere in the classroom. This is also supported by the display on the device screen. E-booster uses 14-size font with double spacing between lines. This is in line with Darroch, et al. (2005) who stated that the font size displayed on a handheld computer (smartphone) must be adjusted to the target reader. Large font sizes (more than 12) are preferred by readers. However, the number of words or texts presented on each page must be considered. The shapes and sizes of the letters legible enough also vary, depends on the spacing between letters or spacing between lines. Spaces are intended to help the eyes recognize blocks of text as a group and help students to easily catch the start of each line. Dyson states that the spacing between lines of text impacts the readers' screen reading speed, thus double spacing is highly recommended (Dyson, 2004).

E-booster's practicality through the efficiency aspect is also supported by hyperlinks that allow students to move pages quickly and ease access on various websites related to learning materials. This finding contradicts the study conducted by Fitzsimmons, et al. (2019) which states that hyperlink effect causes color changing on the text, and change the focus of the readers on sentences that contain hyperlinks instead of the entire text. They believe that it obstructs reading and harms the reader's ability to comprehend the text. However, the hyperlinks in e-booster do not change color, and thus this problem is solved. E-booster also anticipates the number of hyperlinks in the text by replacing them through the magic box feature which is directly linked to the website. Using 3G (third-generation technology) data network, e-booster can be opened in less than ten seconds. The battery power usage of this electronic book is also quite efficient. 87% of students stated that their smartphone battery power remained stable and did not decrease significantly during the use of e-booster. The effectiveness, in terms of battery drainage, is also in line with the requirements which stated that the essence of effective and efficient energy management is represented by the amount of how much energy is consumed by the system (Carroll, 2010).

Effectiveness Test Results

Based on the N-gain score, e-booster's effectiveness result is categorized in the medium rank as the score obtained was 19.804 for t value with 1.68709 for t table and the significance of 2 parties obtained a score of 0.000. Based on the significance, it is smaller than 0.05, so the hypothesis that stated that there is an effect on the use of e-booster on learning physics in enhancing students' academic achievement is acceptable.

The role of e-booster in the effectiveness and improvements in students' academic achievement is performed through the activity called "let's see" which contains sample questions, "let's try" and "let's fight", which contain practice questions as well as formative tests integrated through scientific literacy content (specifically for example questions) and equipped with solutions and answer keys that help students to learn and practice independently. Example questions, practice questions, and formative tests are aimed to guide students in facing final tests.

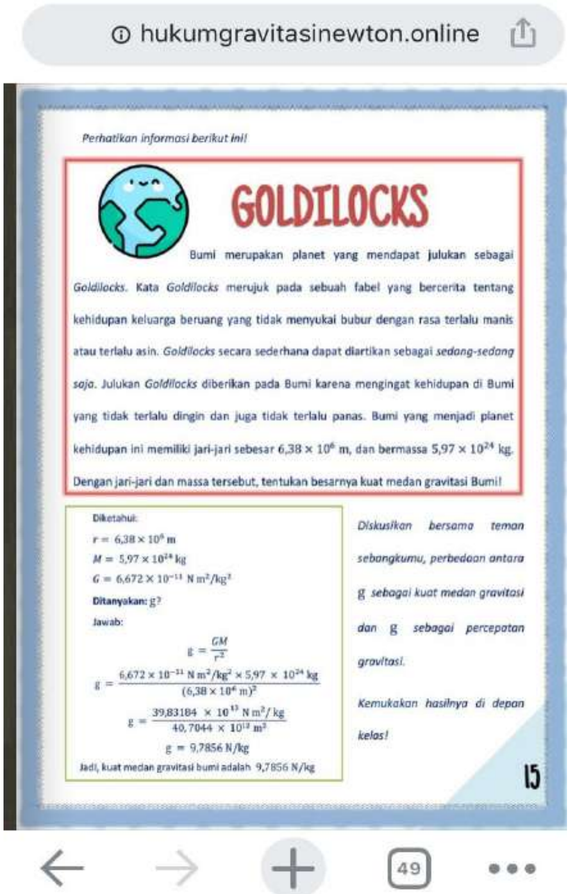

Figure 8. Example problems with scientific literacy content

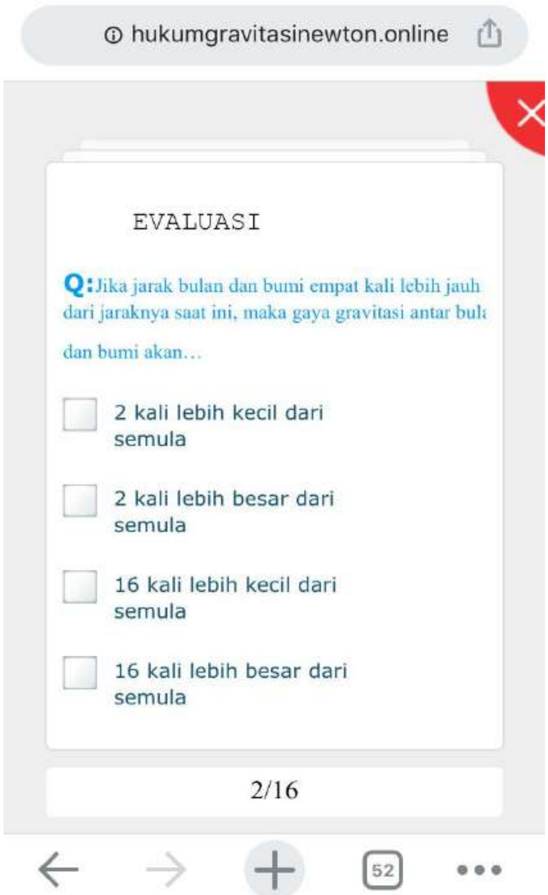

Figure 9. A formative test with scientific literacy content

Scientific literacy application in science learning, especially in physics, is an important component in science education itself (Baram-Tsabari & Yarden, 2005; Knain, 2006). Scientific literacy application in e-booster not only focuses on knowledge transfer, but also facilitates students to gain knowledge through activities which encourage reading and thinking about science and technology. Science and techology are intended so that the knowledge gained from those activities can increase students' interest and help them in solving problems related to learning and life in society (Gucluer & Kesercioglu, 2012).

Reading activities as well as introducing scientific vocabulary activities to students help them assimilate the meaning of vocabulary, which impacted significantly on enhancing their academic achievement (Itza-Ortiz, et al., 2003). Scientific literacy application in e-booster is also effective in increasing academic achievement with the effectiveness results as obtained in Table 2. Kristina states that the use of scientific reading texts in science learning affects students' understanding of scientific concepts more effectively (Gucluer & Kesercioglu, 2012). This is also in line with Güçlüer & Kesercioğlu (2012) which states that the development of scientific literacy in science teaching is a more effective method in increasing academic success.

However, it is necessary to pay more attention to the evaluation used to determine students' learning achievement. Based on the results of learning achievement tests' analysis of multiple-choice questions, it is concluded that multiple-choice questions tend to make respondents emphasize on their memory strengths more and encourage respondents to make guesses (Walstad & Becker, 1994). Meanwhile, based on the analysis of the students' learning outcomes test on essay questions, it was found that some students still had difficulties in numerical skills. Some students still have difficulty in the completion stage of the square root and cube root. There are still students who wrongly completed the comparison equation of $\sqrt{4}:\sqrt{1}$ and 36.84% of students immediately removed the root sign in the comparison equation, so that students get $\sqrt{4}:\sqrt{1} = 4:1$. Even though numerical skill is as a part of calculating operations in mathematics are needed to solve physics problems (Reddy & Panacharoensawad 2017). Therefore, it is hoped that their numerical skills are further trained to support students' academic achievement.

Conclusion

Based on the results of the development and discussion, it is concluded that the validity of e-booster obtained a score of 88.71%, which was categorized as very high. In addition, the practicality obtained 75.39%, which was categorized as practical. Last but not least, the effectiveness from the N-gain score obtained a score of 0.57 which was categorized as medium and significant at α=0,05 which means there is an influence on the use the elekronic book on physics learning to enhance students' academic achievement.

References

Akbar, S. 2016. *Instrumen Perangkat Pembelajaran*. Bandung Barat: PT Remaja Rosdakarya Offset.

Aminah, N. 2016. Kepraktisan model assurance, relevance, interest, assessment, satisfaction (ARIAS) pada pelajaran matematika. *Journal of Mathematics Education: Alpha Math,* 2(2):25–34. https://jurnalnasional.ump.ac.id/index.php/alphamath/article/view/1173.

Anshari, M., Almunawar, M.N., Shahrill, M., Wicaksono, D.K., & Huda, M. 2017. Smartphones usage in the classrooms: learning aid or interference?. *Education and Information Technologies,* 22(6):3063–3079. https://doi.org/10.1007/s10639-017-9572-7.

Aristeidou, M. & Herodotou, C. 2020. Online citizen science: a systematic review of effects on learning and scientific literacy. *Citizen Science: Theory and Practice*, 5(1):1-12. doi: http://doi.org/10.5334/cstp.224.

Bando, R., Gallego, F., Gertler, P., & Fonseca, D.R. 2017. Books or laptops? the effect of shifting from printed to digital delivery of educational content on learning. *Economics of Education Review*, 61:162–173. https://doi.org/10.1016/ j.econedurev.2017.07.005.

Baram-Tsabari, A. & Yarden, A. 2005. Text genre as a factor in the formation of scientific literacy. *Journal of Research in Science Teaching,* 42(4):403–428. https://doi.org/10.1002/tea.20063.

Benešová, A. & Tupa, J. 2017. Requirements for education and qualification of people in industry 4.0. *27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM 2017,* 11:2195–2202. https://doi.org/10.1016/j.promfg.2017.07.366.

Brame, C.J. 2016. Effective educational videos: principles and guidelines for maximizing student learning from video content. *CBE Life Sciences Education,* 15(4):115-122. https://doi.org/10.1187/cbe.16-03-0125.

Branch, R.M. 2009. *Instructional Design: The ADDIE Approach*. Belanda: Springer.

Cansiz, M. & Universitesi, A.C. 2017. *The effect of history of science instruction on elementary students' scientific literacy*. Outu Metu. https://hdl.handle.net/11511/23510.

Carroll, A. & Heiser, G. 2010. An analysis of power consumption in a smartphone. *USENIX Annual Technical Conference*, 14:12-21. https://dl.acm.org/doi/10.5555/ 1855840.1855861#sec-cit

Correia, P.R.M., Xavier do Valle, B., Dazzani, M., & Infante-Malachias, M.E. 2010. The importance of scientific literacy in fostering education for sustainability: theoretical considerations and preliminary findings from a brazilian experience. *Journal of Cleaner Production,* 18(7):678–685. https://doi.org/10.1016/j.jclepro.2009.09.011.

Darroch, I., Goodman, J., Brewster, S., & Gray, P. 2005. The effect of age and font size on reading text on handheld computers. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 46:253–266. https://doi.org/10.1007/11555261_23.

Dyson, M.C. 2004. How physical text layout affects reading from screen. *Behaviour & Information Technology,* 23(6):377–393. https://doi.org/10.1080/01449290410001715714.

Engbrecht, J.R. 2018. Digital textbooks versus print textbooks culminating projects in teacher development. St. Cloud State University. https://repository.stcloudstate.edu/ed_etds/35.

Fitzsimmons, G., Weal, M.J., & Drieghe, D. 2019. The impact of hyperlinks on reading text. *PLoS One,* 14(2):1-20. https://doi.org/ 10.1371/journal.pone.0210900.

Grant, M.C., Fisher, D., & Lapp, D. 2015. *Reading and Writing in Science: Tools to Develop Disciplinary Literacy*. 2nd ed. California: Corwin Press

Grant, M.M. 2019. Difficulties in defining mobile learning: analysis, design characteristics, and implications. *Educational Technology Research and Development,* 67(2):361–388. https://doi.org/10.1007/s11423-018-09641-4.

Grynyuk, S., Kovtun, O., Sultanova, L., Zheludenko, M., Zasluzhena, A., & Zaytseva, I. 2022. Distance learning during the COVID-19 pandemic: the experience of Ukraine's higher education system. *Electronic Journal of E-Learning*, 20(3):242-256. https://doi.org/10.34190/ejel.20.3.2198.

Gucluer, E. & Kesercioglu, T. 2012. The effect of using activities improving scientific literacy on students' achievement in science and technology lesson. *Online Submission,* 1(1):8–13. https://dergipark.org.tr/en/pub/iojpe/issue/69839/1114008

Hake, R.R. 1998. Interactive-engagement versus traditional methods : a six-thousand-student survey of mechanics test data for introductory physics courses interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introduc. *American Association of Physics Teachers*, 66(1):64–74. https://doi.org/10.1119/1.18809.

Hernandez, K.M., Ikpeze, C., & Kimaru, I. 2015. Perspectives on science literacy: a comparative study of united states and kenya. *Educational Research International*, 4(2):25–34. https://fisherpub.sjf.edu/chemistry_facpub/4/.

Hojjati, N. & Muniandy, B. 2014. The effects of font type and spacing of text for online readability and performance. *Contemporary Educational Techonology*, 5(2):161–174. https://dergipark.org.tr/en/pub/cet/issue/25736/271507.

Huda, M., Maseleno, A., Teh, K.S.M., Don, A.G., Basiron, B., Jasmi, K.A., Mustari, M.I., Nasir, B.M., & Ahmad, R. 2018. Understanding modern learning environment (MLE) in big data era. *International Journal of Emerging Technologies in Learning*, 13(5):71–85. https://doi.org/10.3991/ijet.v13i05.8042.

Ihmeideh, F.M. 2014. The effect of electronic books on enhancing emergent literacy skills of pre-school children. *Computers and Education,* 79:40–48. https://doi.org/10.1016/j.compedu.2014.07.008.

Itza-Ortiz, S.F., Rebello, N.S., Zollman, D.A., & Rodriguez-Achach, M. 2003. The vocabulary of introductory physics and its implications for learning physics. *The Physics Teacher,* 41(6):330–336. https://doi.org/10.1119/1.1607802.

Ivey, A. 2010. *Perfect Presentations; How You Can Master the Art of Successful Presenting*. 1st ed. Bookboon.com.

Kasmaienezhadfard, S., Pourrajab, M., & Rabbani, M. 2015. Effects of pictures in textbooks on students' creativity. *Multi Disciplinary Edu Global Quest,* 4(2):83–96. https://www.mdegq.com/paper/effects-pictures-textbooks-students%E2%80%99-creativity.

Kim, H., Agrawal, N., & Ungureanu, C. 2012. Revisiting storage for smartphones. *ACM Transactions on Storage,* 8(4):1-25. https://doi.org/10.1145/2385603.2385607.

Knain, E. 2006. Achieving science literacy through transformation of multimodal textual resources. *Science Education,* 90(4):656–359. https://doi.org/10.1002/sce.20142.

Kurniawan, B., Idris, Purnomo, A., Wiradimadja, A., & Sukamto. 2019. Using broadcasting learning design to enhance student's experiential skill. *International Journal of Emerging Technologies in Learning,* 14(16):172–180. https://doi.org/10.3991/ijet.v14i16.10652.

Lee, O., Llosa, L., Grapin, S., Haas, A., & Goggins, M. 2019. Science and language integration with english learners: a conceptual framework guiding instructional materials development. *Science Education,* 103(2):317–337. https://doi.org/10.1002/sce.21498.

Mang, C., Brown, N., & Piper, L. 2017. 'Old school' meets 'new school': using books and tablets to improve information literacy and promote integrative learning among business students. *International Journal of Management Education,* 15(3):449–455. https://doi.org/10.1016/j.ijme.2017.07.003.

Mehta, R. & Zhu, R.J. 2009. *Blue or Red ? Exploring the Effect of Color on Cognitive Task Performances*. Sciencexpress.

Mourtzis, D., Angelopoulos, J., & Panopoulos, N. 2022. A Literature review of the challenges and opportunities of the transition from industry 4.0 to society 5.0. *Energies*, 15(17): 6276-6281. https:// doi.org/10.3390/en15176276

O'Toole, K.J. & Kannass, K.N. 2018. Emergent literacy in print and electronic contexts: the influence of book type, narration source, and attention. *Journal of Experimental Child Psychology,* 173:100–115. https://doi.org/10.1016/j.jecp.2018.03.013.

Ogunkola, B.J. 2014. Scientific literacy: conceptual overview , importance and strategies for scientific literacy : conceptual overview, importance and strategies for improvement. *Journal of Educational and Social Research,* 3(1):265–274. https://doi.org/10.5901/jesr.2013.v3n1p265.

Reddy, M.V.B. & Panacharoensawad, B. 2017. Students problem-solving difficulties and implications in physics: an empirical study on influencing factors. *Journal of Education and Practice,* 8(14):59–62. https://eric.ed.gov/?id=EJ1143924.

Rohmawati, A. 2015. Efektivitas pembelajaran. *Jurnal Pendidikan Usia Dini,* 9(1):15–32. https://journal.unj.ac.id/unj/index.php/jpud/article/view/3491.

Rusdi, M. 2018. *Penelitian Desain dan Pengembangan Kependidikan*. Depok: PT. Raja Grafindo Persada.

Rusilowati, A., Nugroho, S.E., & Susilowati, S.M. 2016. Development of science textbook based on scientific literacy for secondary school. *Jurnal Pendidikan Fisika Indonesia,* 12(2):98–105. https://doi.org/10.15294/jpfi.v12i2.4252.

Sa'aleek, R.A. 2018. A content analysis of the colors in the efl textbook of action pack. *British Journal of Education, Learning and Development Psychology,* 1(1):57–65. https://abjournals.org/bjeldp/papers/volume-1/issue-1/a-content-analysis-of-the-colors-in-the-efl-textbook-of-action-pack/.

Sarwono, J. 2015. *Rumus-Rumus Populer Dalam SPSS 22 Untuk Riset Skripsi.* Yogyarta: Andi Offset.

Sayono, J., Jauhari, N., Ayundasari, L., & Sulistyo, W.D. 2020. Development of projo bale model based on android application in history and local wisdom studies of Malang. *International Journal of Emerging Technologies in Learning,* 15(7):4–16. https://doi.org/10.3991/IJET.V15I07.13219.

See, B.H. & Gorard, S. 2020. Effective classroom instructions for primary literacy: a critical review of the causal evidence. *International Journal of Educational Research,* 102:1-16. https://doi.org/10.1016/j.ijer.2020.101577.

Seftari, V., Milama, B., & Saridewi, N. 2018. The development of chemistry textbook based on scientific literacy the concept of colloid system. *3rd International Conferences on*

Education in Muslim Society (ICEMS 2017), 115(95):208–214. https://doi.org/10.2991/icems-17.2018.40.

Sulistyo, W.D. & Kurniawan, M.N.L.K.B. 2020. The Development of 'jeger' application using android platform as history learning media and model. *International Journal of Emerging Technologies in Learning,* 15(7):110–122. https://doi.org/10.3991/IJET.V15I07.11649.

Susak, M. 2016. *Participation factors that affect classroom (Theses).* Croatia: Rochester Institute of Technology. https://scholarworks.rit.edu/theses/9370/.

Tong, J. 2016. Design and implementation of music teaching platform in college based on android mobile technology. *International Journal of Emerging Technologies in Learning,* 11(5):4–9. https://doi.org/10.3991/ijet.v11i05.5686.

Turgut, H. 2007. Psikolojik ölçme aracı uyarlama. *Journal of Faculty of Educational Sciences,* 40(2):233–256. https://doi.org/10.1501/Egifak.

Turiman, P., Omar, J., Daud, A.M., & Osman, K. 2012. Fostering the 21st century skills through scientific literacy and science process skills. *Procedia - Social and Behavioral Sciences,* 59:110–116. https://doi.org/10.1016/j.sbspro.2012.09.253.

Walstad, W.B. & Becker, W.E. 1994. Achievement differences on multiple-choice and essay tests in economics business administration, college of achievement differences on multiple-choice and essay tests in economics. *American Economic Review,* 84(2):193–196. https://www.jstor.org/stable/2117827.

Wei, W. & Xia, W. 2016. The Improvement of students' scientific literacy based on biology concept teaching. *4th International Education, Economics, Social Science, Arts, Sports and Management Engineering Conference (IEESASM 2016)*, 751–754. https://doi.org/10.2991/ieesasm-16.2016.156

Wen, C.T., Liu, C.C., Chang, H.Y., Chang, C.J., Chang, M. H., Fan, C.S.H., Yang, C.W., & Hwang, F.K. 2020. Students' guided inquiry with simulation and its relation to school science achievement and scientific literacy. *Computers and Education*, 149:1-14. https://doi.org/10.1016/j.compedu.2020.103830.

Wilkinson, J. 1999. A quantitative analysis of physics textbooks for scientific literacy themes. *Research in Science Education,* 29(3):385–399. https://doi.org/10.1007/BF02461600.

Zen, E. 1990. Science literacy and why it is important. *Journal of Geological Education*, 38(5):463–464. https://doi.org/10.5408/0022-1368-38.5.463.

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Feasibility of Using Conservation Education Learning Devices for Class X High School Students

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Abstract. The curriculum in Indonesia has not yet implemented the conservation education model in learning, so there are no learning devices with this model in Indonesian schools, therefore it is necessary to carry out research regarding the preparation of conservation learning devices. This study aims to determine the feasibility of learning devices for conservation education in class X SMA. The research method used is R&D using the ADDIE model which is limited to the development stage (analysis, design, development). The learning devices developed consisted of lesson plans, worksheets, power points, modules, and evaluation questions, then their feasibility was tested by being validated by five validators and analyzed using Aiken'S V to determine validity and intraclass correlation coefficient (ICC) was used to determine reliability. The research instrument used was a validation sheet. The results showed that the validity value of the lesson plan was 0.89, the worksheet was 0.86, the power point was 0.88, the module was 0.88, and the evaluation item was 0.88 and all were included in the category of very high content. The results of lesson plan reliability 0.933, LKPD 0.937, power point 0.898, module 0.973, and evaluation item were 0.939 and all included in the very good category. It can be concluded that the conservation education learning devices for class X SMA are appropriate to use.

Keywords: conservation education, feasibility, learning devices

Introduction

At present the environment is one problem faced by many countries. Environmental problems had a large impact which began to be felt in the 1950s, proving that environmental problems had existed since ancient times and the discussion was endless (Hardati, et al., 2015; Atmaja, et al., 2020; Wardani & Yuanita, 2020). There are various types of causes of environmental problems, based on data from the united nations framework convention on climate change (UNFCCC) global environmental problems can be caused by climate change, damage to the ozone layer, the greenhouse effect, and acid rain (Proistosescu, et al., 2018; Septiadi & Yasa, 2021).

The development of the globalization era is increasing and this condition has both positive and negative impacts on life (Díaz, et al., 2019; Nugraha, et al., 2021; Marcelina, et al., 2022). One of the negative impacts is that it can lead to human behavior that can damage the environment (Michael, et al., 2020; Sriyati, et al., 2022). Furthermore, dependence on the environment makes humans the main subject in utilizing natural resources but sometimes makes humans forget, causing damage (Nugroho & Puspitasari, 2019; Nugraha, et al., 2021). This is in line with a study in the intergovernmental panel on climate change (IPCC) in 2007 explaining that human activity is one of the main causes of increasing concentrations of greenhouse gasses in the earth's atmosphere which in turn can cause global warming and climate change (Fattah, 2013; Subiyanto et al., 2018).

One way to protect the environment is through environmental education because it is able to educate individuals so that they have attitudes and skills in protecting and maintaining the preservation of nature and can be rationally included in the curriculum (Widaningsih, 2010; Aripin, 2017). Success in forming human resources to implement the principles of sustainable development can run smoothly with environmental education because it is a factor that plays an active role in creating this success (Landriany, 2014). Based on data from the belgrade charter a global framework for environmental education, the aim is to increase awareness and concern, and creating a unified pattern of behavior (Bactiar, 2007; Sardjono, 2011).

Environmental education can be poured in the form of conservation in the school environment. This is because means preservation or preserved (Rahman, 2013) so that it can be used as a means to protect the environment. Meanwhile, education can be a place to build character so that it is in harmony with nature and society (Nurkholis, 2013). Conservation education in schools can awaken students to have concern for the environment (Türkoĝlu, 2019; O'Malley & Pierce, 2022). Human action is always based on stimulation, therefore conservation attitudes need to be encouraged so that they can be carried out and affect the environment can have a positive impact, including stabilizing hydrological functions, protecting soil, conserving resources, and maintaining environmental quality (Sutarman, 2013; Wulandari, 2017; Sakurai & Uehara, 2020). Schools can organize several programs that support conservation education activities by involving the participation of school members and the school environment in the learning component in the classroom (Johnson-Pynn & Johnson, 2010; Aguilar-Jurado, et al., 2019).

Based on the results of interviews at the Adiwiyata school, namely SMAN 2 Mempawah, it is known that the school has a program designed to preserve the environment. Based on the results of interviews at the Adiwiyata school, SMAN 1 Mempawah, it is known that the school has extracurricular activities that are carried out to protect and care for the environment. For the two Adiwiyata schools, they do not yet have conservation education learning devices and only apply a little to learning materials. Based on the results of interviews at a non-adiwiyata school, namely SMAN 2 Pontianak, it is known that this school has a program implemented to preserve the environment called clean Friday but due to the Covid-19 pandemic this is no longer implemented. This school also does not have conservation education learning devices.

Conservation education is not material contained in the syllabus, but can be integrated into several subjects, one of which is environmental change material because learning that is oriented towards caring for the environment will restore awareness. It is also making a culture of loving the environment as character (Zuchdi & Darmiyati , 2011; Nardi & Narut, 2019; Spooner, et al., 2021). Conservation education has the goal of providing understanding and increasing environmental care attitudes so that they can solve problems that occur (Rachman, 2012; Göbel, 2022). The 2013 curriculum has not implemented conservation as a subject matter in learning. The 2013 curriculum that focuses on a balance of knowledge, character education and skills that can educate students (Husna, et al., 2020). Many students do not yet have the character of understanding environmental care (Hafida & Wahid, 2018; Türkoğlu, 2019). Conservation is necessary for human survival (Ardoin, et al., 2019; Nugraha, et al., 2021). Learning about conservation can be implemented in environmental change material. This is in line with the results of Landriany (2014) and Aripin (2017) which states that the attitude of students' concern for the environment is still low, so conservation education needs to be taught to students, especially in class X because it is a transitional period from junior high school to senior high school so this attitude needs to be instilled in them because character building takes a long time (Nardi & Narut, 2019). The 21st century requires students to build character and critical thinking skills in order to be creative in solving problems and making decisions (Sriyati, et al., 2021).

In the delivery of learning about conservation education to students can be equipped with devices that support. Learning devices are a complement to the implementation of the process and can be arranged based on the applicable curriculum because can improve students' competence in the field of cognitive and communication skills (Masitah, 2018; Asmar & Suryadarma, 2021). The conservation education learning devices that have been prepared are implemented in the biology subject matter of environmental change in class X even semester. The purpose of this study was to determine the feasibility of conservation education learning devices for class X high school students.

Methods

This research uses the development method (research and development) referring to the ADDIE model which is limited to the analysis, design, and development stages (Dewi, 2018). The stages of this research included gap analysis of conservation education learning tools, preparation and development, validation, and revision based on suggestions from the five validators. The preparation stage is carried out by interviewing the school about the learning tools used. The next stage is analyzing the syllabus, determining basic competency (KD), indicators, and developing learning materials that include environmental changes. The preparation of learning tools is also done by determining the components of learning devices such as in the lesson plan (RPP), student worksheets (LKPD), power points, modules, and evaluation questions, as well as formats including letters, images, colors, layout, and margins. The next stage is the validation of learning devices, while the aspects assessed in the RPP include aspects of the formulation of learning objectives, material, language, and time. LKPD assessment includes three aspects, namely material, language, and presentation. Power point assessment includes material and appearance. The aspects assessed in the module are delivery technique, presentation feasibility, and graphic feasibility, while evaluation questions include clarity, content accuracy, relevance, content validity, no bias, and language accuracy. The sampling technique used was simple random sampling by selecting an expert as a validator to test the feasibility of the learning device with a total of five validators. The data collection technique was obtained from the learning device validation sheet. The data analysis technique used is the feasibility assessment of the learning device resulting from the five validators. The final stage is the analysis of the data from the results of the five validators. The validation results that have been obtained from the five validators are then analyzed to determine their validity using Aiken's V referring to Harmuni (2019). In this study the results of the validation were also tested for reliability using the intraclass correlation coefficient (ICC) (Koo & Li, 2016).

Results and Discussion

Learning devices for conservation education are the result of the development and analysis of the syllabus for class X high school students on environmental change material. The learning devices developed in this study consisted of lesson plans, worksheets, power points, modules, and evaluation questions. The learning device developed is material for class X environmental change in accordance with the syllabus by implementing the concept and implementation of conservation in schools. It is proven that the attitude of concern for the environment is still low, therefore teachers can make students aware that they can have this through carried out both inside and outside the classroom, because student are important in learning (Landriany, 2014; Aripin, 2017). Some of the results of previous research indicate that to determine the feasibility of learning devices a validation process is carried out (Rahmatillah, et al., 2017; Setiawan, et al., 2021; Panjaitan, et al., 2022). The results of the validity of the lesson plan are presented in Table 1.

Table 1. The results of validity of the lesson plans for conservation education for class X high school students

Aspects	Indicator	Validator					Validity	Information
		1	2	3	4	5		
Formulation of learning objectives	1. Clarity of basic competence	3	3	4	4	4	0.93	Content validity very high
	2. Conformity between KD and learning objectives	3	4	4	4	4		
	3. Completeness of RPP components	4	4	4	4	4		
	4. Conformity of indicators with objectives	3	4	4	4	4		
	5. Appropriateness of indicators with students' abilities	3	3	4	4	4		
Theory	6. Appropriateness of indicators with students' abilities	3	4	4	4	3	0.89	Content validity very high
	7. The subject matter is in accordance with the learning objectives	3	4	4	4	3		
	8. Learning materials contain facts, concepts, procedures	3	4	4	4	4		
	9. Conformity with learning resources	3	4	4	4	4		
	10. The accuracy of the selection of learning media	3	4	4	4	3		
	11. Clarity of the arrangement of learning steps	3	4	4	4	3		
Language	12. Clarity of grammar	3	3	4	3	4	0.87	Content validity very high
	13. Communicative language	3	3	4	4	4		
	14. Simplicity of sentence structure	3	4	4	4	4		
Time	15. Appropriateness of the time allocation used	3	4	3	4	4	0.87	Content validity very high
Averages							0.89	Content validity very high

Formulation Aspects of Learning Objectives

The learning objective of this lesson plan is that students can cultivate an attitude of caring for the environment. RPP assessment on the formulation aspect of learning objectives obtained a value of 0.93 including the category of very high content validity. In the aspect of formulating, there are five indicators, namely clarity, suitability between KD and learning objectives, indicators with students' abilities, completeness of lesson plans components. The first is the clarity of learning objectives. Based on the results of the validator's assessment, the learning objectives in the lesson plan are clear and in accordance with the syllabus. According to Budiastuti, et al. (2021) and Marianti, et al. (2022), a quality lesson plan is that it contains learning objectives according to the learning concept so that it can increase one's willingness to learn. The second is the suitability between KD and learning objectives. Based on the KD validator assessment contained in the lesson plan already has conformity with the learning objectives based on the even semester class X biology syllabus (Figure 1). According to Indaryanti, et al. (2019) and Saputri, et al. (2023), in developing learning objectives must be aligned with KD so that students can increase knowledge according to their abilities. The third is the completeness of the RPP components. RPP components based on the validator's assessment are complete and clear. The lesson plan components in this study refer to the Minister of Education and Culture Regulation No. 22 of 2016 which consists of 13 components, namely: (1) school identity, (2) subject identity, (3) class/semester, (4) subject matter, (5) time allocation, (6) learning objectives, (7) KD and GPA, (8) learning materials, (9) learning methods, (10) learning media, (11) learning resources, (12) learning steps, (13) assessment of learning outcomes. Fourth is the suitability of indicators with objectives.

RENCANA PELAKSANAAN PEMBELAJARAN

(PERTEMUAN PERTAMA)

Sekolah	: Sekolah Menengah Atas
Pelajaran	: Biologi
Kelas/Semester	: X/Genap
Materi Pokok	: Perubahan Lingkungan/Iklim dan Daur Ulang Limbah
Alokasi Waktu	: 2 x 45 menit

A. Kompetensi Inti

KI 1 : Menghayati dan mengamalkan ajaran agama yang dianutnya

KI 2 : Menghayati dan mengamalkan perilaku jujur, disiplin, peduli (toleransi, gotong royong), santun, percaya diri, tanggungjawab, responsif dan proaktif dalam berinteraksi secara efektif sesuai dengan perkembangan anak di lingkungan, keluarga, sekolah, masyarakat dan lingkungan alam sekitar, bangsa, negara, kawasan regional, dan kawasan internasional.

KI 3 : Memahami, menerapkan, dan menganalisis pengetahuan faktual, konseptual, prosedural, metakognitif berdasarkan rasa ingin tahunya tentang ilmu pengetahuan, teknologi, seni budaya, dan humaniora dengan wawasan kemanusiaan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena atau kejadian, serta menerapkan pengetahuan prosedural pada bidang kajian yang spesifik sesuai bakat dan minatnya untuk memecahkan masalah.

E. Metode Pembelajaran

1. Pendekatan : Saintifik
2. Model pembelajaran : *Discovery Learning*
3. Metode : Diskusi kelompok, tanya jawab, penugasan

F. Media dan Sumber Belajar

1. Media
   a. LKPD
   b. Gambar yang berhubungan dengan kerusakan lingkungan, ketidakseimbangan lingkungan.
   c. *Slide Power Point*
2. Sumber belajar
   a. Modul pendidikan konservasi
   b. Buku yang berhubungan dengan materi lingkungan, serta pendidikan konservasi
   c. Website (e-jurnal, ebook, dan sumber lain yang dapat dipertanggung jawabkan)

G. Langkah-Langkah Pembelajaran

1. Pertemuan Ke-1 (2 x 45 menit)	**Waktu**
Kegiatan Pendahuluan **Guru :** **Orientasi** *(Menunjukkan sikap disiplin sebelum memulai proses pembelajaran, menghayati dan mengamalkan ajaran agama yang dianut (Karakter) serta membiasakan membaca dan memaknai (Literasi).* ❖ Melakukan pembukaan dengan salam pembuka dan berdoa untuk memulai pembelajaran*(PPK: Religius)*	**15 menit**

(a) RPP identity (b) Method, resources, and steps in RPP

Figure 1. Formulation of core competencies, basic competencies, indicators, and learning objectives (in Bahasa)

Based on the assessment of the validator, the indicators and objectives made are appropriate and contain conservation and do not release the subject matter of environmental change according to the syllabus. Indicators are key in learning, so the formulation of indicators must be clear and in accordance with the objectives so that learning activities become more effective (Indaryanti, et al., 2019; Asmar & Suryadarma, 2021). Fifth is the suitability of indicators with students' abilities. Indicators as the key to learning must be adapted to students' abilities so that in implementing student learning it is easy to follow them (Febrian & Fera, 2019; Nugraha, et al, 2021).

Theory Aspects

The validator's assessment of the material aspect obtained a value of 0.89 including the category of very high content validity. In the material aspect, there are six indicators, namely suitability between KD and materials, subject matter in accordance with objectives, contain facts, concepts, and procedures, compatibility with resources, accuracy in choosing media, and clarity of the arrangement of learning steps. The first is the suitability between KD and learning materials. Based on the KD validator's assessment and the material in the lesson plan it is clear that it is in accordance with the syllabus. According to Anggraeni & Akbar (2018) the material in lesson plans must be appropriate and aligned with KD so that can be achieved and create active learning. The second is the subject matter according to the learning objectives. Based on the validator's assessment of the subject matter contained in the RPP, it is in accordance with the learning objectives and contains the concept and application of conservation in schools. Third, the material contains facts, concepts, and procedures. Based on the assessment of the material validator in the RPP, there are facts, concepts, and procedures that are appropriate and clear and contain based on the main material in the syllabus (Figure 1b). Facts, concepts, and procedures that are appropriate to the material will facilitate learning (Widoretno, et al., 2016) the material used in RPP is environmental change. Fourth is suitability with learning resources. Based on the assessment of the RPP validator, it contains clear and appropriate learning resources. Using appropriate learning resources will support the learning process (Kamil, 2018; Nugroho & Puspitasari, 2019). Fifth is the accuracy of media selection. Media as a support in the learning process will assist in delivering material in learning (Kamil, 2018; Habibati, et al., 2019). Sixth is the clarity of the arrangement of steps in learning. Based on the validator's assessment, the learning steps in the lesson plan are appropriate and in accordance with the learning model used.

Language Aspects

The validator's assessment of the language aspect obtained a value of 0.87 in the category of very high content validity. In the aspect of language there are three indicators. The first indicator is the clarity of grammar. Based on the validator's assessment, the language used was clear and appropriate, but there was a slight improvement in the writing because there were some writing errors (Figure 2). The second indicator is the language used communicatively. Communicative language will make it easier to read every sentence (Panjaitan, et al., 2021). The third indicator is the simplicity of sentence structure. Based on the validator's assessment, the sentence structure used is simple and easy to understand. With regard to language, some researchers stated that clear language will make it easier for readers to understand a text (Anggraeni & Akbar, 2018; Linda, et al., 2021).

E. Metode Pembelajaran

1. Pendekatan : Saintifik

2. Model pembelajaran : *Discovery Learning*

3. Metode : Diskusi kelompok, tanya jawab, penugasan

F. Media dan Sumber Belajar

1. Media

a. LKPD

b. Gambar yang berhubungan dengan kerusakan lingkungan, ketidakseimbangan lingkungan.

c. *Slide Power Point*

2. Sumber belajar

a. Modul pendidikan konservasi

b. Buku yang berhubungan dengan materi lingkungan, serta pendidikan konservasi

c. Website (e-jurnal, ebook, dan sumber lain yang dapat dipertanggung jawabkan)

G. Langkah-Langkah Pembelajaran

1. Pertemuan Ke-1 (2 x 45 menit)	**Waktu**
Kegiatan Pendahuluan **Guru :** **Orientasi** *(Menunjukkan sikap disiplin sebelum memulai proses pembelajaran, menghayati dan mengamalkan ajaran agama yang dianut (Karakter) serta membiasakan membaca dan memaknai (Literasi).* ❖ Melakukan pembukaan dengan salam pembuka dan berdoa untuk memulai pembelajaran*(PPK: Religius)*	**15 menit**

(a) Method and learning resources (b) Learning steps

Figure 2. Presentation of language in RPP (in Bahasa)

Aspects of Time

The validator's assessment of the time aspect obtained a value of 0.87 including the category of very high content validity. In the time aspect, there is only one indicator, namely the suitability of the time allocation used (Figure 3). Based on the validator's assessment, the time allocation used was in accordance with the time in the syllabus namely with two hours of lessons and four meetings. A good lesson plan if the implementation is according to the time in the syllabus (Nur, et al., 2020).

RENCANA PELAKSANAAN PEMBELAJARAN

(PERTEMUAN PERTAMA)

Sekolah : Sekolah Menengah Atas

Pelajaran : Biologi

Kelas/Semester : X/Genap

Materi Pokok : Perubahan Lingkungan/Iklim dan Daur Ulang Limbah

Alokasi Waktu : 2 x 45 menit

Figure 3. Allocation of time in RPP (in Bahasa)

This research also developed conservation education worksheets. In the following, the results of the validity of the conservation education worksheets for class X students are presented based on the assessment of the five validators in Table 2.

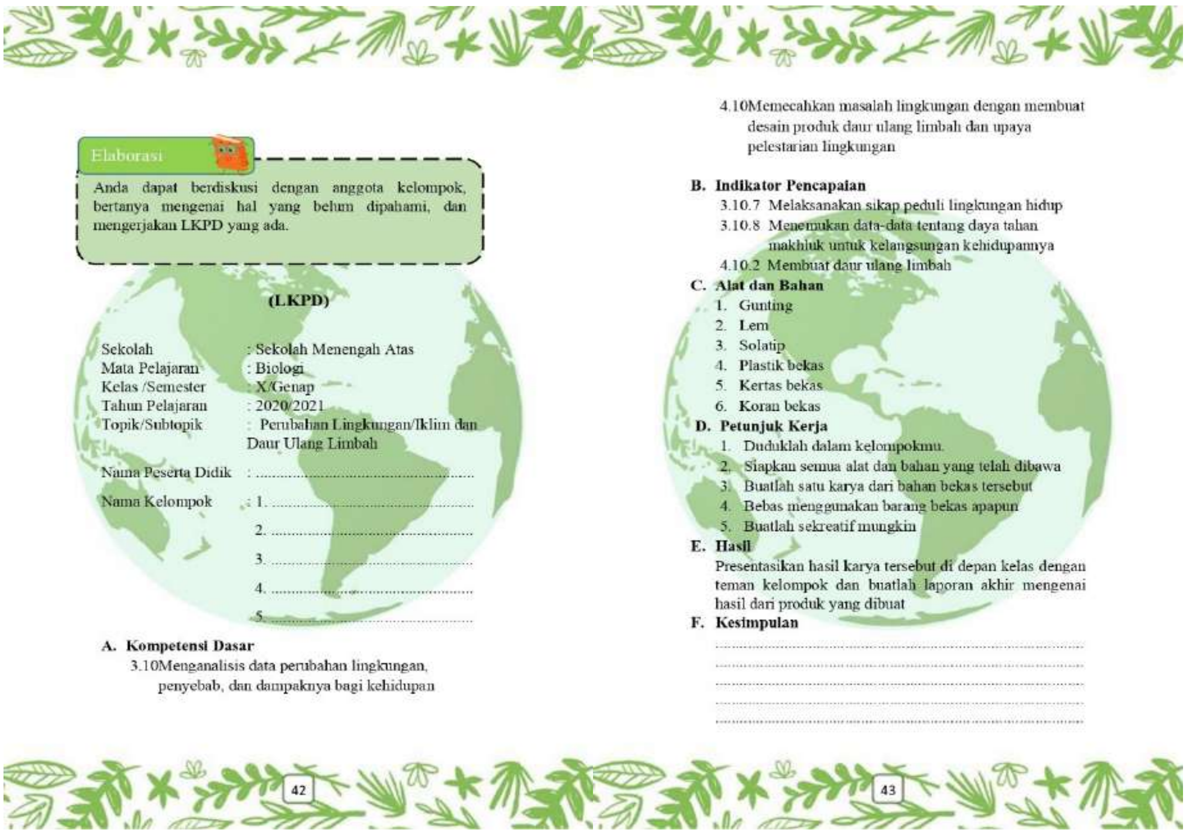
Table 2. Results of the validity of the conservation education worksheets for class X students

Aspects	Indicator	Validator 1	2	3	4	5	Validity	Information
Theory	1. The accuracy of the title of the LKPD with the contents of the material	3	4	4	4	4	0.90	Content validity very high
	2. The truth of the content of the material	3	3	4	4	4		
	3. Truth by method	3	3	4	4	4		
	4. Compatibility with KD	3	4	4	4	3		
	5. Appropriateness of the material with the ability of students	3	3	4	4	4		
	6. Clarity of material distribution	3	4	4	4	4		
Language	7. Grammatical correctness	3	3	4	3	4	0.84	Content validity very high
	8. Sentences do not contain double meaning	3	3	4	4	4		
	9. Clarity of instructions and directions	3	3	4	4	4		
Presentation	10. Image Quality	3	3	4	4	4	0.84	Content validity very high
	11. Attractive display design	3	3	3	4	4		
	12. Clarity of writing	3	3	3	4	4		
	13. Appropriate font type and size	3	4	3	4	4		
	14. The accuracy of the placement of the picture table or chart on each question	3	4	4	4	3		
	Average						0.86	Content Validity Very High

Aspects of Theory

The LKPD assessment on the material aspect obtained a value of 0.90 including the category of very high content validity. In this aspect there are six indicators. The first indicator is the accuracy of the LKPD title with the content of the material. Based on the validator's assessment of the title on the LKPD it is in accordance with the contents of the LKPD. Choosing the right title will describe the content of the reading and attract readers' interest (Wardani & Yuanita, 2020). The second indicator is the truth of the content of the material. Based on the assessment of the material validator in the LKPD it is clear and there are instructions that can be carried out by students. The material used in LKPD is environmental change and in LKPD there are learning steps according to the model used. The right content makes students understand and understand what is being learned (Rahmatillah, et al., 2017; Laksono & Wibowo, 2022). The third indicator is truth with method. Based on the assessment of the developed LKPD validator it is in accordance with the learning method used. The fourth indicator is suitability with KD. The developed LKPD contains KD based on the syllabus that has been analyzed (Figure 4). According to Anggraeni & Akbar (2018) material must be appropriate and aligned with KD so that learning objectives can be achieved and create active learning. The fifth indicator is the suitability of the material with the students' abilities. Based on the assessment of the

LKPD validator, it has been made in accordance with students' abilities and uncovers problems that exist in the environment around students (Fauziah, et al., 2022). Learning that links problems around the environment where students live will help students understand more quickly, increase thinking power and make learning more meaningful (Diella, et al., 2019; Marianti, et al., 2022). The sixth indicator is the clarity of material distribution. The division of material must be made clear, sequentially systematic, and contain material based on the syllabus (Anggraeni & Akbar, 2018).



(a) Title and LKPD identity procedure

(b) Achievement indicator and

Figure 4. Display of titles, KD, indicators, and work instructions on LKPD (in Bahasa)

Aspects of Language

The LKPD assessment on the language aspect obtained a value of 0.84 in the category of very high content validity. The language aspect consists of three indicators. The first indicator is grammatical correctness. Based on the validator's assessment, the clarity of the grammar is appropriate, communicative, and easy to understand. Systematic and clear language will help the reader to understand the meaning of the reading (Linda, et al., 2021). The second indicator is that the sentence does not contain multiple meanings. Based on the validator's assessment, there are no sentences with double meaning in the LKPD (Figure 5). Double meaning in sentences will make it difficult for readers to understand reading (Linda, et al., 2021; Panjaitan, et al., 2021). The third indicator is the clarity of instructions and directions. Based on the validator's assessment, the instructions for working on the LKPD are clear and contained in the LKPD. Clear instructions can help students carry out learning (Masitah, 2018).

Figure 5. Language display in LKPD (in Bahasa)

Aspects of Presentation

The LKPD assessment on the presentation aspect obtained a value of 0.84 in the category of very high content validity. The presentation aspect of the LKPD consists of five indicators. The first indicator is image quality. Based on the assessment of the image validator, it should be made more attractive so that students become interested. The second indicator is the attractiveness of the display design. Based on the assessment from the validator, the LKPD display can be made more attractive so that students become interested in LKPD. An attractive appearance will create an attraction for readers (Lestari, et al., 2018). The third indicator is the clarity of writing. The writing on the LKPD is clear and easy to understand both from the instructions, indicators, and the questions in it are clear and do not contain double meanings. The fourth indicator is the appropriate font type and size. Based on the validator's assessment, the type and size of the letters used are appropriate (Figure 4). The LKPD developed uses times new roman 12 font type and size. The fifth indicator is the accuracy of the placement of tables, pictures or parts of each question. Based on the validator's assessment, the placement of tables in the LKPD is neat and clear so that the meaning is easy to understand. LKPD is good and correct if the presentation is systematic, sequential, and has clear components (Rahmatillah, et al., 2017; Masitah, 2018).

In this study also developed a conservation education power point. In the following, the results of the power point validity of class X students' conservation education are presented based on the assessment of the five validators in Table 3.

Table 3. The results of the power point validity of conservation education

Aspects	Indicator	Validator					Validity	Information
		1	2	3	4	5		
Theory	1. The accuracy of the material with the competency standards contained in the curriculum	3	4	4	4	4	0.89	Content validity very high
	2. The suitability of the material with the basic competencies contained in the curriculum	4	4	4	4	3		
	3. Conformity of the description of the material contained in multimedia products with scientific concepts	3	3	4	4	4		
	4. Clarity of media product assignment targets	3	3	4	4	4		
	5. Adequacy of material descriptions in explaining scientific concepts	3	4	3	4	4		
	6. Sufficient examples are given for explanation	3	4	3	4	4		
Presentation	7. Text and writing can be read	3	3	3	4	4	0.88	Content validity very high
	8. Color combinations	4	3	4	4	4		
	9. Consistency of button placement	3	4	4	4	3		
	10. Image display quality	3	4	4	4	4		
	11. Text and image layout	3	4	4	4	4		
	12. Screen display quality	3	4	4	4	4		
	Averages						0.88	Content Validity very high

Aspect of Theory

Assessment of material aspects on power point obtained a value of 0.89 in the category of very high content validity. In the material aspect, there are six indicators. The first indicator is the accuracy of the material with the competency standards contained in the curriculum. Based on the validator's assessment of the competency standards in the power point, it is in accordance with the material discussed. The second indicator is the suitability of the material with the basic competencies contained in the curriculum. Based on the validator's assessment, the material contained in power point is in accordance with the basic competencies in the syllabus (Figure 6). The scope of material contained in learning media cannot be separated from the syllabus (Indaryanti, et al., 2019). The third indicator is the suitability of the sequence of material contained in multimedia products with scientific concepts. Based on the validator's assessment, the order of the material contained in the power point is appropriate and sequential. The appropriate sequence of material will make it easier to understand the material (Nurseto, 2011). The fourth indicator is the clarity of targets for the use of media products. Based on the validator's assessment of the target use of the media it is clear that it is used for teachers and students. The teacher as a facilitator will help students understand the material through learning media (Kamil, 2018; Habibati, et al., 2019; Nugroho & Puspitasari, 2019). The fifth indicator is the adequacy of material descriptions in explaining concepts. The sixth indicator is the adequacy of examples given for explanation. Based on the validator's assessment, the example is clear enough, equipped with pictures so that it can increase student understanding. Clear and relevant examples will make it easier to understand the material (Nurrita, 2018; Linda, et al., 2021).

(a) Home page (b) Environmental education

Figure 6. Presentation of material in PPT (in Bahasa)

Aspects of Display

In the power point display aspect, a value of 0.88 was obtained in the category of very high content validity. In the display aspect, there are six indicators. The first indicator is text and writing can be read. Based on the validator's assessment, the writing in power point is clear and readable. The second indicator is the color combination. Based on the validator's assessment, the color combinations used in PowerPoint are quite interesting and appropriate to the material presented (Figure 7). Interesting color combinations can foster reader interest in using learning media so that learning can run effectively (Habibati, et al., 2019; Panjaitan, et al., 2022). The third indicator is the consistency of button placement. Based on the validator's assessment, the placement of buttons in power point is consistent and does not change. The fourth indicator is the quality of the image display. Based on the assessment of the quality of the image display is quite good and the size of the image can be enlarged. The fifth indicator is the layout of text and images. Based on the validator's assessment, the layout of the text and images is clear and appropriate so that the intent of the images can be understood easily. Easy-to-understand learning will make it easier for students to achieve learning goals (Rahmatillah, et al., 2017; Budiastuti, et al., 2021; Marianti, et al., 2022). The sixth indicator is the quality of the screen display. Based on the validation results of the five display validators used in power point, it can be made more contrast with the right color and background selection. The choice of power point as a learning medium is because can display presentations in the form of images, videos, sounds and interesting animations, designed to run on its own according to the duration made, easy to manufacture and use. This is also evidenced by Kamil's opinion, (2018) that power point has advantages, namely: (1) practical and can be used for all classes, (2) provides the possibility of face-to-face meetings and observing student responses, (3) has an interesting variety of presentation techniques and not boring, (4) can present various combinations of clipart, picture, color, animation, and sound so as to make students more interested, (5) can be used repeatedly.

(a) Cover page

(b) Home page

(c) Environmental damage

(d) Material content

Figure 7. Display content in PPT (in Bahasa)

In this study also developed a conservation education module. In the following, the results of the validity of the conservation education module for class X students are presented based on the assessment of the five validators in Table 4.

Table 4. The results of the validity of the conservation education module

Aspects	Indicator	Validator					Validity	Information
		1	2	3	4	5		
Presentation technique	1. Systematic presentation	3	3	4	4	4	0.87	Content validity very high
	2. Confused presentation	3	3	4	4	4		
Presentation eligibility	3. Introductory section	3	4	4	4	4	0.91	Content validity very high
	4. Content section	3	4	4	4	4		
	5. Concluding part	3	4	4	4	3		
Graphical eligibility	6. Conformance of size with ISO standards	3	4	4	4	4	0.88	Content validity very high
	7. Layout	3	3	4	4	4		
	8. Layout composition and size	3	3	4	4	4		
	9. Letters	3	4	4	4	4		
	10. Reflection of content	3	3	4	4	4		
	11. Layout harmony	3	3	4	4	4		
	12. Complete layout	3	3	4	4	4		
Averages							0.88	Content validity very high

Aspects of Presentation Technique

The evaluation of the module on the presentation technique aspect obtained a value of 0.87 including the category of very high content validity. In the technical aspect of the presentation consists of two indicators. The first indicator is systematic presentation. Based on the validator's assessment, the presentation of the module is systematic and easy to understand. Systematic presentation of modules can facilitate their use (Husna, et al., 2020). The second indicator is the coherence of the presentation. Based on the assessment of the validator, the presentation of the module is sequential and in accordance with the module components (Figure 8). In this study the module components used refer to Prastowo (2015), namely: (1) title, (2) preface, (3) table of contents, (4) background (5) brief description, (6) competency standards, (7) concept maps, (8) benefits, (9) learning objectives, (10) instructions for using modules, (11) basic competencies, (12) subject matter, (13) material descriptions, (14) headings, (15) summary, (16) exercises or assignments, (17) self-test, (18) post-test, (19) follow-up, (20) expectations, (21) glossary, (22) bibliography, (23) answer key.

7 

DAFTAR ISI

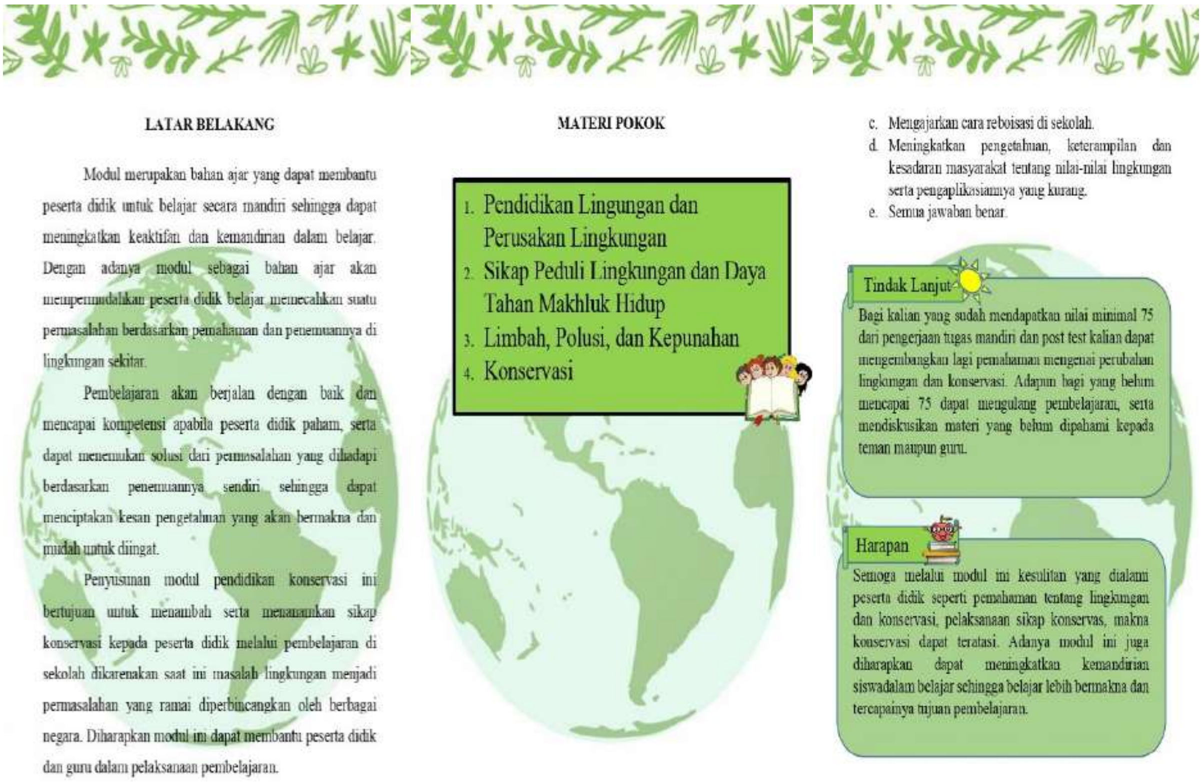
(a) Before Revision

(b) After Revision

Figure 8. View of the presentation of the conservation education module (in Bahasa)

Aspects of Presentation Feasibility

The module assessment on the presentation feasibility aspect obtained a value of 0.91 including the very high content validity category. In the feasibility aspect of the presentation consists of three indicators. The first indicator is the introduction. Based on the validator's assessment in the introductory section it is complete and in accordance with the module components used. The introductory section contains the background of the module (Figure 9). An appropriate introduction will describe the contents of the teaching materials (Kurniasih & Rahayu, 2017; Nugroho & Puspitasari, 2019). The second indicator is the content section. Based on the validator's assessment, the content section is complete in sequence and contains material that is in accordance with the biology syllabus for class X. The material used in this module is environmental change. The suitability of the material contained in the module makes it easier for students to carry out learning according to the instructions in the module (Magdalena, et al., 2020; Apriani, et al., 2021; Lewar & Suhartini, 2023). The third indicator is the cover. Based on the validator's assessment, the closing section is clear and equipped with exercises, follow-up, and expectations for students. The existence of training and follow-up can measure the level of understanding of students (Aripin, 2017; Magdalena, et al., 2020; Marianti, et al., 2022).

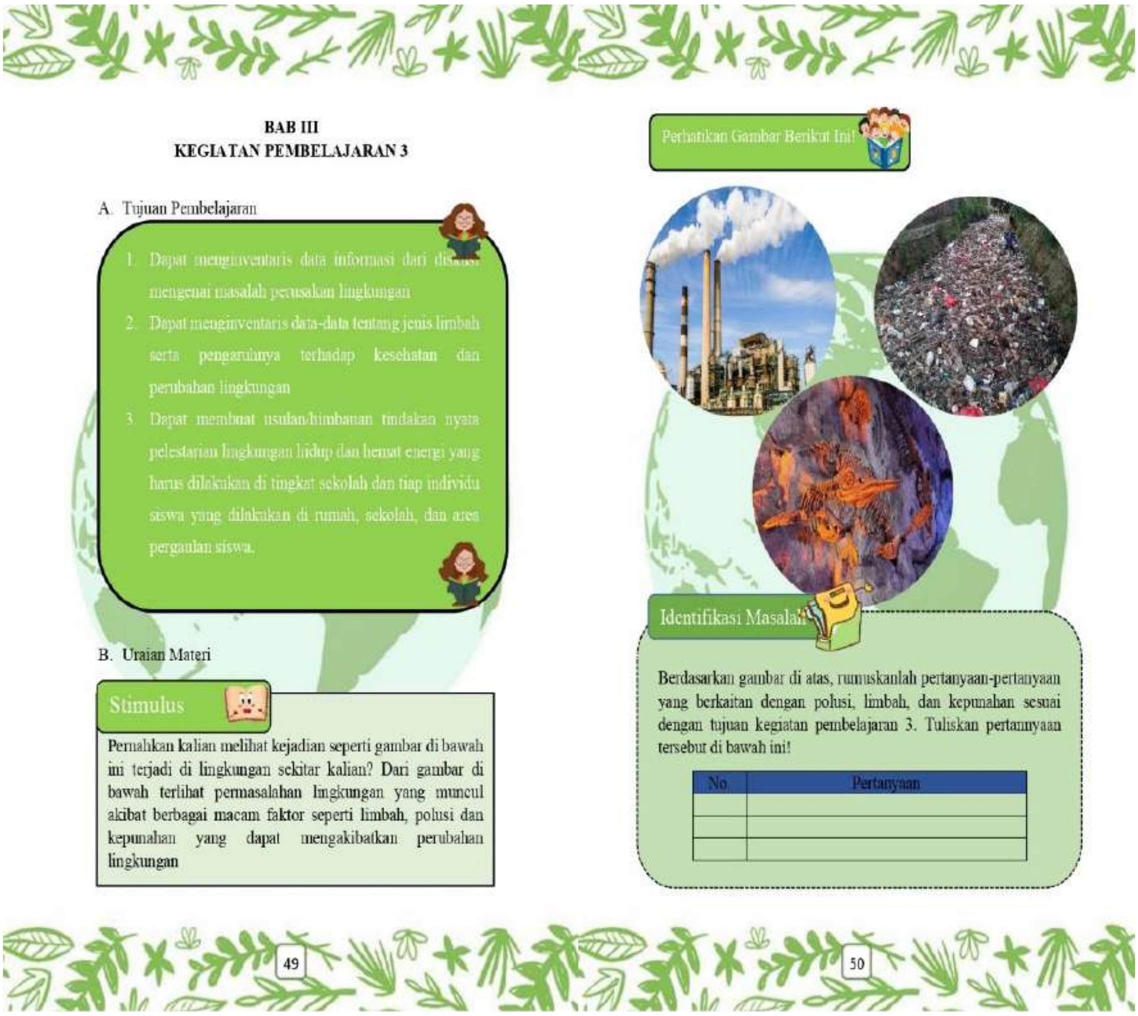


(a) Background page (b) Subject matter in the module (c) Closing page

Figure 9. Display the introduction, body, and closing sections (in Bahasa)

Graphic Feasibility Aspects

Module assessment on the aspect of graphic feasibility obtained a value of 0.88 including the category of very high content validity. In the aspect of graphic feasibility, it consists of eight indicators. The first indicator is conformity in size with ISO standards. Based on the assessment of the module size validator according to ISO size, namely using sizes based on international standards according to UNESCO, namely measuring 15.5 x 23 cm. The second indicator is layout (Permana, et al., 2018). Based on the validator's assessment, the layout in the module is correct and neat. Layout accuracy can affect the contents of the module, correct layout accuracy will make it easier to use the module (Husna, 2020; Laksono & Wibowo, 2022). The third indicator is layout composition and size. Based on the validator's assessment, the composition and layout of the module is complete and in accordance with the module components. Appropriate module components will assist students in learning using modules (Laksono & Wibowo, 2022). The fourth indicator is letters. In this module, the font type times new roman size 12 is declared appropriate. The suitability of the font size will affect the readability of the module (Setiyaningsih & Syamsudin, 2019). The fifth indicator is content reflection. Reflection of the content in the module according to the material discussed and made based on the syllabus. Appropriate content will facilitate understanding (Indaryanti, et al., (2019). The sixth indicator is layout harmony. Based on the validator's assessment, harmony and layout are precise and clear. Good layout harmony affects the appearance of the module so it will help the reader in understand what is read (Budiastuti, et al., 2021; Linda, et al., 2021). The seventh indicator is the completeness of the layout. Based on the validator's assessment, the layout in the module already has good completeness based on the module components used (Figure 10). The eighth indicator is content typography. Based on the validator's assessment there are still some typography in the contents of the module, there are a few errors in writing words. Accuracy in writing letters and words can affect readers in understanding the meaning of the reading (Setiyaningsih & Syamsudin, 2019; Linda, et al., 2021).



(a) Learning activities 3 in the module (b) Problem in the environment

Figure 10. Graphic display on the module (in Bahasa)

This research also develops conservation education evaluation questions. In the following, the results of the validity of the conservation education evaluation questions for class X students are presented based on the assessment of the five validators in Table 5.

Table 5. Results of the validity of the evaluation questions

Aspects	Indicator	Validator					Validity	Information
		1	2	3	4	5		
Clarity	1. Clarity of each item	3	3	4	4	4	0.87	Content validity very high
	2. Clarity of instructions for filling in questions	3	3	4	4	4		
Content accuracy	3. Language accuracy	3	3	4	4	4	0.87	Content validity very high
	4. The accuracy of the question form	3	4	4	3	3		
Relevance	5. Items related to the material	3	4	4	4	4	0.93	Content validity very high
Content validity	6. The level of grain truth	3	3	4	4	4	0.87	Content validity very high
No bias	7. The item contains a complete idea	3	3	4	4	4	0.90	Content validity very high
	8. The words used do not have a double meaning	3	4	4	4	4		
Language accuracy	9. The language used is easy to understand	3	4	4	4	3	0.89	Content validity very high
	10. The language used is effective	3	3	4	4	4		
	11. Language according to EYD	3	4	4	4	4		
Averages							0.88	Content validity very high

Aspect of Clarity

Assessment on the aspect of clarity obtained a value of 0.87 including the category of very high content validity. The aspect of clarity consists of two indicators. The first indicator is the clarity of each item. Based on the assessment of the item validator, the items already have appropriate clarity and are easy to understand. The suitability of the item items will help students understand the intent of the question so that it makes it easier to work on (Magdalena, et al., 2020; Ramadhani, et al., 2021). The second indicator is the clarity of the instructions for filling in the questions. Based on the assessment the module validator already has clear instructions for filling in the questions so that students can find out the work of the questions (Figure 11). Instructions will help in giving directions on what to do (Wardani & Yuanita, 2020).


Post Test

Pilihlah jawaban yang paling benar dari soal di bawah ini!

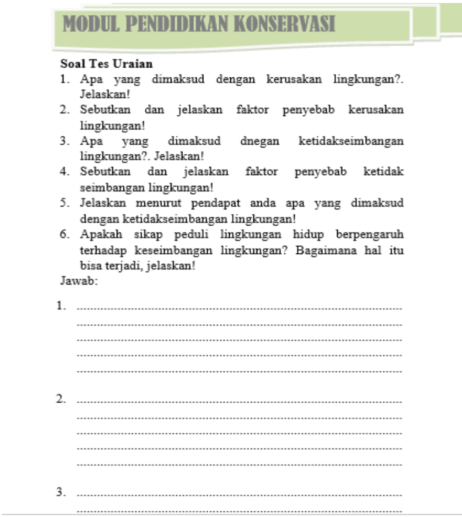
1. Lingkungan hidup telah diatur dalam perundang-undangan yang ada di Indonesia. Berikut ini undang-undang yang tepat mengenai lingkungan hidup adalah.....
   a. Undang-undang No. 33 Tahun 2009 tentang pengertian lingkungan hidup.
   b. Undang-undang No. 32 Tahun 2009 tentang pengertian lingkungan hidup dan ekosistem.
   c. Undang-undang No. 32 Tahun 2009 tentang perlindungan dan pengelolaan lingkungan hidup.
   d. Undang-undang No. 33 Tahun 2009 tentang perlindungan dan pengelolaan lingkungan hidup
   e. Undang-undang No. 32 Tahun 2009 tentang kerusakan lingkungan.

2. Kerusakan lingkungan cenderung banyak terjadi di wilayah perkotaan dibandingkan dengan wilayah pedesaan. Hal ini dikarenakan banyaknya populasi serta pola tingkah laku yang beragam di wilayah perkotaan. Apa hubungan populasi serta pola tingkah laku terhadap kerusakan lingkungan.....
   a. Semakin banyak populasi maka akan menciptakan lingkungan yang lestari dan terjaga.
   b. Semakin banyak populasi maka akan semakin beragam pola tingkah laku yang dapat menyebabkan kerusakan lingkungan.
   c. Kepadatan populasi dan tingkah lakunya tidak berpengaruh terhadap lingkungan.

Figure 11. Display of grain clarity and workmanship instructions (in Bahasa)

Aspects of Content Accuracy

Assessment on the aspect of content accuracy obtained a value of 0.87 including the category of very high content validity. In the aspect of accuracy of the content consists of two indicators. The first indicator is the accuracy of the language. Based on the assessment of the language validator used in the questions, it is clear and precise. Using the right language will help readers understand (Linda, et al., 2021; Panjaitan, et al., 2021). The second indicator is the accuracy of the question form. Based on the assessment the validator asks to add multiple choice questions to the evaluation questions (Figure 12). The existence of practice questions can measure the extent to which students understand and increase student knowledge (Aripin, 2017; Magdalena, et al., 2020; Ramadhani, et al., 2021).



MODUL PENDIDIKAN KONSERVASI

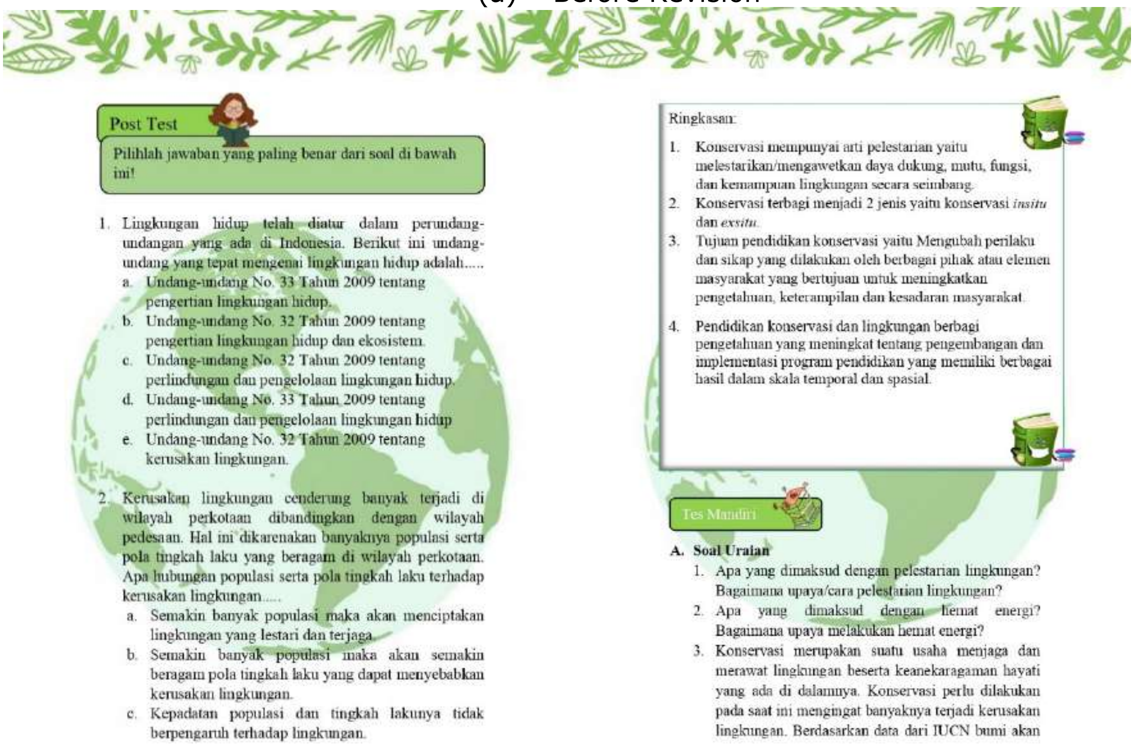
Soal Tes Uraian

1. Apa yang dimaksud dengan kerusakan lingkungan?. Jelaskan!
2. Sebutkan dan jelaskan faktor penyebab kerusakan lingkungan!
3. Apa yang dimaksud dnegan ketidakseimbangan lingkungan?. Jelaskan!
4. Sebutkan dan jelaskan faktor penyebab ketidak seimbangan lingkungan!
5. Jelaskan menurut pendapat anda apa yang dimaksud dengan ketidakseimbangan lingkungan!
6. Apakah sikap peduli lingkungan hidup berpengaruh terhadap keseimbangan lingkungan? Bagaimana hal itu bisa terjadi, jelaskan!

Jawab:

1. ....
2. ....
3. ....

(a) Before Revision



Post Test

Pilihlah jawaban yang paling benar dari soal di bawah ini!

1. Lingkungan hidup telah diatur dalam perundang-undangan yang ada di Indonesia. Berikut ini undang-undang yang tepat mengenai lingkungan hidup adalah.....
   a. Undang-undang No. 33 Tahun 2009 tentang pengertian lingkungan hidup.
   b. Undang-undang No. 32 Tahun 2009 tentang pengertian lingkungan hidup dan ekosistem.
   c. Undang-undang No. 32 Tahun 2009 tentang perlindungan dan pengelolaan lingkungan hidup.
   d. Undang-undang No. 33 Tahun 2009 tentang perlindungan dan pengelolaan lingkungan hidup
   e. Undang-undang No. 32 Tahun 2009 tentang kerusakan lingkungan.
2. Kerusakan lingkungan cenderung banyak terjadi di wilayah perkotaan dibandingkan dengan wilayah pedesaan. Hal ini dikarenakan banyaknya populasi serta pola tingkah laku yang beragam di wilayah perkotaan. Apa hubungan populasi serta pola tingkah laku terhadap kerusakan lingkungan.....
   a. Semakin banyak populasi maka akan menciptakan lingkungan yang lestari dan terjaga.
   b. Semakin banyak populasi maka akan semakin beragam pola tingkah laku yang dapat menyebabkan kerusakan lingkungan.
   c. Kepadatan populasi dan tingkah lakunya tidak berpengaruh terhadap lingkungan.

Ringkasan:

1. Konservasi mempunyai arti pelestarian yaitu melestarikan/mengawetkan daya dukung, mutu, fungsi, dan kemampuan lingkungan secara seimbang.
2. Konservasi terbagi menjadi 2 jenis yaitu konservasi *insitu* dan *exsitu*.
3. Tujuan pendidikan konservasi yaitu Mengubah perilaku dan sikap yang dilakukan oleh berbagai pihak atau elemen masyarakat yang bertujuan untuk meningkatkan pengetahuan, keterampilan dan kesadaran masyarakat.
4. Pendidikan konservasi dan lingkungan berbagi pengetahuan yang meningkat tentang pengembangan dan implementasi program pendidikan yang memiliki berbagai hasil dalam skala temporal dan spasial.

Tes Mandiri

A. Soal Uraian

1. Apa yang dimaksud dengan pelestarian lingkungan? Bagaimana upaya/cara pelestarian lingkungan?
2. Apa yang dimaksud dengan hemat energi? Bagaimana upaya melakukan hemat energi?
3. Konservasi merupakan suatu usaha menjaga dan merawat lingkungan beserta keanekaragaman hayati yang ada di dalamnya. Konservasi perlu dilakukan pada saat ini mengingat banyaknya terjadi kerusakan lingkungan. Berdasarkan data dari IUCN bumi akan

(b) After Revision

Figure 12. Display the contents of evaluation questions (in Bahasa)

Aspect of Relevance

Assessment on the aspect of relevance obtained a value of 0.93 including the category of very high content validity. The relevance aspect consists of one indicator, namely the items related to the material. Based on the assessment of the item validator in accordance with the material discussed, namely environmental change and conservation by raising problems that exist around students, because problems that exist around students and are experienced directly will be easy to understand and remember

(Kurniasari & Rahayu, 2017). This is same with Erlindawati & Habibati, (2020); Nugraha, et al., (2021); Sriyati, et al (2022) stating that problems associated with the environment, especially where students live will increase students' environmental literacy. The suitability between the items and the material will make it easier for students to work on the questions (Febrian & Fera, 2019).

Aspect of Content Validity

Assessment on the aspect of content validity obtained a value of 0.87 including the category of very high content validity. The aspect of content validity consists of one indicator, namely the level of item truth. Based on the assessment of the content validator, the questions have been made according to the students' abilities. The suitability of learning with students' abilities and problems will make learning effective (Nurseto, 2011; Indaryanti, et al., 2019; Marianti, et al., 2022; Nurdiyanti, et al., 2022).

Aspect of No Bias

The assessment on the unbiased aspect obtained a value of 0.90 including the category of very high content validity. The no bias aspect consists of two indicators. The first indicator is a question item containing a complete idea. Completeness of ideas makes it easier to understand the purpose of the problem. Understanding the questions makes it easier for students to work on questions (Maulida, et al., 2019; Ramadhani, et al., 2021). The second indicator is the words used do not have a double meaning. Based on the validator's assessment, the evaluation questions were clear and did not contain double meanings, according to the material and complete with answer keys.

Aspect of Language Accuracy

Assessment on the aspect of language accuracy obtained a value of 0.89 including the category of very high content validity. In the aspect of language accuracy consists of three indicators. The first indicator is the language used is easy to understand. Based on the assessment of the language validator used in the questions are simple and easily understood by students (Figure 11). The simplicity of language will help students work on questions so that no mistakes occur in the process (Linda, et al., 2021; Mayasari & Habeahan, 2021). The second indicator is the language used effectively. Based on the assessment of the language validator used, it is effective, easy to understand and does not have double meaning. The effectiveness of a sentence will affect its readability (Linda, et al., 2021; Panjaitan, et al., 2022). The third indicator is writing according to the EYD. The conformity of the EYD rules needs to be considered in writing so that sentences do not contain double meanings so they are easy to understand. According to Anggraeni & Akbar (2018) and Linda, et al. (2021) that clear language will make it easier for readers to understand a text.

Apart from seeing the level of validity, the learning devices developed in this study are also seen for the level of reliability by using the ICC formula (Koo & Li, 2016). The results of the study obtained the average value of the reliability of the learning devices developed, namely lesson plans of 0.933, worksheets of 0.937, power points of 0.898, modules of 0.973, evaluation questions of 0.939 included in the good category based on the average range of index ≥0.75 (Koo & Li, 2016). This shows agreement among raters in declaring that the developed learning tool is valid and feasible to use.

Conclusion

The results showed that the validity value of the lesson plan was 0.89, the LKPD was 0.86, the power point was 0.88, the module 0.88, and the evaluation item was 0.88 and all were included in the category of very high content. The results of lesson plan reliability were 0.933, LKPD 0.937, power point 0.898, module 0.973, and evaluation item 0.939 and all included in the very good category. It can be concluded that the conservation education learning devices for class X SMA are appropriate to use.

References

Aguilar-Jurado, M.A., Gil-Madrona, P., Ortega-Dato, J.F., & Zamorano-García, D. 2019. Effects of an educational glass recycling program against environmental pollution in Spain. *International Journal of Environmental Research and Public Health*, 16(24):1-16. https://doi.org/10.3390/ijerph16245108.

Anggraeni, P. & Akbar, A. 2018. Kesesuaian rencana pelaksanaan pembelajaran dan proses pembelajaran. *Jurnal Pesona Dasar*, 6(2):55-65. https://doi.org/10.24815/pear.v6i2.12197.

Apriani, R., Harun, A.I., Erlina, Sahputra, R., & Ulfah, M. 2021. Pengembangan modul berbasis multipel representasi dengan bantuan teknologi augmented reality untuk membantu siswa memahami konsep ikatan kimia. *JIPI (Jurnal IPA dan Pembelajaran IPA),* 5(4):305-330. https://doi.org/10.24815/jipi.v5i4.23260.

Ardion, N.M., Bowers, A.W., & Gaillard, E. 2019. Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, 241:1-13. https://doi.org/10.1016/j.biocon.2019.108224.

Aripin, I. 2017. Pembelajaran pendidikan lingkungan hidup berorientasi 3R (reuse, reduce and recycle) untuk meningkatkan kreativitas dan sikap peduli lingkungan. *Jurnal Bio Educatio*, 2(2):1-11. http://jurnal.unma.ac.id/index.php/BE/article/download-SuppFile/754/43.

Asmar, A. & Suryadarma, I.G.P. 2021. Pengembangan perangkat pembelajaran IPA terpadu model nested berbasis perahu phinisi untuk meningkatkan keterampilan komunikasi dan pengetahuan konseptual. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(4):565-578. https://doi.org/10.24815/jpsi.v9i4.20994.

Bactiar, I.G. 2007. Peranan pendidikan luar sekolah dalam pembangunan berwawasan lingkungan. *Perspektif Ilmu Pendidikan*, 15(7):66-70. https://doi.org/10.21009/PIP.151.11.

Budiastusi, P., Soenarto, S., Muchlas, & Ramndani, H.W. 2021. Analisis tujuan pembelajaran dengan kompetensi dasar pada rencana pelaksanaan pembelajaran dasar listrik dan elektronika di Sekolah Menengah Kejuruan. *Jurnal Edukasi Elektro*, 5(1):39-48. https://journal.uny.ac.id/index.php/jee.

Díaz, I.A., Lucena, F.J.H., Reche, M.P.C., Torres, J.M.T., & Rodríguez, J.M.R. 2019. Environmental attitudes in trainee teachers in primary education the future of biodiversity preservation and environmental pollution. *International Journal of Environmental Research and Public Health*, 16(3):1-11. https://doi.org/10.3390/ijerph16030362.

Diella, D., Ardiansyah, R., & Suhendi, H.Y. 2019. Pelatihan pengembangan LKPD berbasis keterampilan proses sains dan instrumen asesmen KPS bagi guru IPA. *Publikasi Pendidikan*, 9(1):7–11. https://doi.org/10.26858/publikan.v9i1.6855.

Erlindawati & Habibati. 2020. Penerapan model discovery learning untuk meningkatkan aktivitas dan hasil belajar peserta didik pada materi termokimia. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(1):92-104. https://doi.org/10.24815/jpsi.v8i1.16099.

Fauziah, A., Rahman, T., & Samsudin, A. 2022. Pentingnya lembar kerja peserta didik ipa berbasis metakognitif untuk melatih kemampuan berpikir kritis dan pemecahan masalah terhadap siswa SMP. *JIPI (Jurnal IPA dan Pembelajaran IPA),* 6(4):365-368. https://doi.org/10.24815/jipi.v6i4.27355.

Febrian, F., & Fera, M. 2019. Kualitas perangkat dan keterampilan mengajar mahasiswa pendidikan matematika pada mata kuliah micro teaching menggunakan analisis model rasch. *Jurnal Gantang*, 4(1):87-95. https://doi.org/10.31629/jg.v4i1.1065.

Göbel, B. 2022. Environmental education and its challenges to foster attitudes. *Biosphere Reserves Management*, 1-9. https://doi.org/10.13140/RG.2.2.14295.14244.

Habibati, Hasan, M., & Fitri, N.R. 2019. Pengembangan media buletin menggunakan corel-draw X7 pada materi pencemaran lingkungan. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 7(1):23-33. https://doi.org/10.24815/ jpsi.v7i1.13514.

Hafida, N. & Wahid, A.H. 2018. Pembentukan karakter peduli dan berbudaya lingkungan bagi peserta didik di Madrasah melalui program Adiwiyata. *Fikrotuna: Jurnal Pendidikan dan Manajemen Islam*, 8(2):950-971. https://doi.org/10.32806/jf.v8i2.3295.

Hardati, P., Setyowati, D.L.N., Wilonoyudho, S., Martuti, N.K.T., & Utomo, A.P.Y. 2015. *Pendidikan konservasi*. Pustaka Utama, Semarang.

Harmurni, L. 2019. *Instrumen penilaian & validasinya*. Uwais Inspirasi Indonesia, Ponorogo.

Husna, A., Hasan, M., Mustafa, Syukri, M., & Yusrizal. 2020. Pengembangan modul fisika berbasis integrasi islam-sains pada materi gerak lurus untuk meningkatkan hasil belajar peserta didik. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(1):55-66. https://doi.org/10.24815/jpsi.v8i1.15539.

Indaryanti, Susanti, E., Aisyah, N., & Seristia. 2019. Analisis kesesuaian indikator terhadap kompetensi dasar pada pelajaran matematika oleh guru Sekolah Menengah Palembang. *Jurnal Gantang*, 4(2):103-109. http://ojs.umrah.ac.id/index.php/gantang/index.

Johnson-Pynn, J.S. & Johnson L.R. 2010. Successes and challenges in East African conservation education. *The Journal of Environmental Education*, 36(2):25-39. https://doi.org/10.3200/JOEE.36.2.25-39.

Koo, T., & Li, M. 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, 15(2):63-155. https://doi.org/10.1016/j.jcm.2016.02.012.

Kurniasih, D. & Rahayu, H.M. 2017. Pengembangan perangkat pembelajaran kimia analitik materi kromatografi berorientasi inkuiri terbimbing. *Jurnal Pendidikan Matematika dan IPA*, 8(2):31-40. http://dx.doi.org/10.26418/jpmipa.v8i2.

Laksono, R.K.S. & Wibowo, Y. 2022. Pengembangan bahan ajar berbasis socio-scientific issues untuk meningkatkan higher order thinking skill. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(4):752-765. https://doi.org/10.24815/jpsi.v10i4.25719.

Landriany, E. 2014. Implementasi kebijakan adiwiyata dalam upaya mewujudkan pendidikan lingkungan hidup di SMA Kota Malang. *Jurnal Kebijakan dan Pengembangan Pendidikan*, 2(1):82-103. https://ejournal.umm.ac.id/index.php/jkpp/article/view/1739/1834.

Lewar, A.K. & Suhartini. 2023. Pengembangan modul berbentuk scrapbook pada materi sistem saraf untuk meningkatkan hasil belajar siswa SMA kelas XI. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1):96-112. https://doi.org/10.24815/jpsi.v10i4.26980.

Linda, R., Zulfarina, Mas'ud, & Putra, T.P. 2021. Peningkatan kemandirian dan hasil belajar peserta didik melalui implementasi e-modul interaktif IPA terpadu tipe connected pada materi energi SMP/MTs. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education*, 2(1):18-29. https://doi.org/10.24815/jpsi.v9i2.19012.

Magdalena, I., Sundari, T., Nurkamilah, S., Nasrullah, & Amalia, D.A. 2020. Analisis bahan ajar. *Nusantara: Jurnal Pendidikan dan Ilmu Sosial*, 2(2):311-326. https://ejournal. stitpn.ac.id/index.php/nusantara.

Masitah. 2018. Pengembangan perangkat pembelajaran untuk memfasilitasi guru menumbuhkan rasa tanggung jawab siswa SD terhadap masalah banjir. *Jurnal Proceeding Biology Education Conference*, 15(1):41-49.

Marcelina, S., Miranda, Y., & Sinaga, S. 2022. Implementasi model pembelajaran predict-observe-explain berbasis masalah terhadap keterampilan proses sains dan pemahaman konsep pada topik pencemaran lingkungan. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(4):705-716. https://doi.org/10.24815/jpsi.v10i4.25846.

Marianti, D., Kurniati, T., & Kurniasih, D. 2022. Pengembangan lembar kerja mahasiswa berbasis science, environment, technology, and society di program studi pendidikan kimia Universitas Muhammadiyah Pontianak. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 6(3):219-234. https://doi.org/10.24815/jipi.v6i3.2512.

Maulida, R.F., Darmawan, P., & Prayekti, N. 2019. Analisis pemahaman siswa dalam menyelesaikan soal cerita terkait teorema Pythagoras. *Prosiding Seminar Nasional MIPA UNIBA*, 10(2):198-20.

Mayasari, D. & Habeahan, N.L.S. 2021. Analisis kemampuan pemahaman konsep siswa dalam menyelesaikan soal cerita matematika. *Jurnal Aksioma*, 10(1):252-261. http://dx.doi.org/10.24127/ajpm.v10i1.3265.

Michael, J., McPhaden, Agus, S., & Wenju, C. 2020. Science ENSO in the CMIP5 simulations: life cycles, diversity, and responses to climate change. *Journal Climate*, 30(2):775–801. https://doi.org/10.1175/JCLI-D-15-0901.

Nardi, M. & Narut, Y.F. 2019. Analisis sikap peduli lingkungan pada siswa kelas VI sekolah dasar di Kota Ruteng. *Jurnal Pendidikan dan Kebudayaan*, 9(3):259-266. https://doi.org/10.24246/j.js.2019.v9.i3.p259-266.

Nurdiyanti., Wadji, M., & Fadhilah, N. 2022. Validitas dan kepraktisan modul digital berbasis socio scientific issue. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 5(1):15-35. https://doi.org/10.24815/jipi.v6i1.23461.

Nugraha, F., Permanasari, A., & Pursitasari, I.D. 2021. Disparitas literasi lingkungan siswa Sekolah Dasar di Kota Bogor. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 6(1):33-44. https://jurnal.unsyiah.ac.id/JIPI/article/view/17744.

Nugroho, P.A. & Puspitasari, Y.D. 2019. Pengembangan modul praktikum pencemaran lingkungan berbasis inkuiri terbimbing berkolaborasikan video untuk meningkatkan sikap peduli lingkungan dan hasil belajar mahasiswa. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 3(2):42-61. https://jurnal.unsyiah.ac.id/JIPI/article/view/14549/11389.

Nurkholis. 2013. Pendidikan dalam upaya memajukan teknologi. *Jurnal Kependidikan*, 1(1):26-30. http://ejournal.uin-suka.ac.id.

Nurrita, T. 2018. Pengembangan media pembelajaran untuk meningkatkan hasil belajar siswa. *Misykat: Jurnal ilmu-ilmu Al-Quran, Hadits, Syariah dan Tarbiyah*, 3(1):171-187. https://doi.org/10.33511/misykat.v3n1.171-187.

Nurseto, T. 2021. Membuat media pembelajaran yang menarik. *Jurnal Ekonomi dan Pendidikan*, 8 (1):19-35. https://doi.org/10.21831/jep.v8i1.706.

O'Malley, S. & Pierce, J. 2020. Mainstream or margins? the changing role of environmental education in irish primary school curricula, 1872 to 2021. *Journal of Outdoor and Environmental Education*. 1-18. https://doi.org/10.1007/s42322-022-00118-w.

Panjaitan, R.G.P., Titin, & Wahyuni, E.S. 2021. Kelayakan booklet inventarisasi tumbuhan berkhasiat obat sebagai media pembelajaran. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(1):11-21. https://doi.org/10.24815/jpsi.v9i1.17966.

Panjaitan, R.G.P., Titin, & Wahyuni, E.S. 2022. Kelayakan media pembelajaran booklet buah Hyphaene thebaeca (L.) Mart. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(1):125-137. https://doi.org/10.24815/jpsi.v10i1.22402.

Prastowo, A. 2015. *Panduan kreatif membuat bahan ajar inovatif*. Diva Press, Yogyakarta.

Proistosescu, C., Donohoe, A., Armour, K.C., Roe, G.H., Stuecker, M.F., & Bitz C.M. 2018. Radiative feedbacks from stochastic variability in surface temperature and radiative imbalance. *Geophysical Research Letter*, 45:1-13. https://doi.org/10.1029/2018GL077678.

Rachman, M. 2012. Pengembangan pendidikan karakter berwawasan konservasi nilai-nilai sosial. *Forum Ilmu Sosial*, 40(1):5-9. http://journal.unnes.ac.id.

Ramadhani, D.P., Asrizal, & Festiyed. 2021. Analisis effect size pengaruh penerapan LKS terhadap hasil belajar siswa pada pembelajaran IPA dan Fisika. *JIPI (Jurnal IPA dan Pembelajaran IPA),* 5(1):77-89. https://doi.org/10.24815/jipi.v5i1.19607.

Rahmatillah, Halim, A., & Hasan, M. 2017. Pengembangan lembar kerja peserta didik berbasis keterampilan proses sains terhadap aktivitas pada materi koloid. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 1(2):121-130. https://doi.org/10.24815/jipi.v1i2.9686.

Sakurai, R. & Uehara, T. 2020. Effectiveness of a marine conservation education program in Okayama, Japan. *Conservation Science and Practice*, 2(3):16-22. https://doi.org/10.1111/csp2.167.

Saputri, Y.D., Adi, B.S., Hastuti, W.S., & Murti, R.C. 2023. Peningkatan kemampuan mahasiswa pendidikan guru dalam menyusun perangkat pembelajaran melalui refleksi diri pada mata kuliah pendidikan IPA sekolah dasar. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education*, 11(1):40-49. https://doi.org/10.24815/jpsi.v10i4.26790.

Sardjono, W. 2011. Model pelestarian lingkungan hidup berbasis teknologi informasi pada aktivitas sosialisasi berbasis masyarakat sebagai sentra partisipan. *ComTech:Computer, Mathematics and Engineering*, 2(1):368-372. https://doi.org/10.21512/comtech.v2i1.2765.

Sartika, R.P. & Hadi, L. 2015. Pengembangan perangkat pembelajaran model siklus belajar 5E pada materi hukum dasar kimia dalam meningkatkan hasil belajar mahasiswa. *Jurnal Pendidikan Matematika dan IPA*, 6(1):26-37. http://dx.doi.org/10.26418/jpmipa.v6i1.16219.

Septiadi, A.A.M.N.P. & Yasa, M.M. 2021. Kekuatan mengikat paris agreement kepada negara-negara anggotanya. *Jurnal Kertha Desa*, 9(8):13-21. https://ojs.unud.ac.id/index.php/kerthadesa/article/view/76337.

Setiawan, M.N., Kandowangko, N.Y., & Yusuf, F.M. 2021. Validasi perangkat pembelajaran pada materi keanekaragaman hayati di kelas X SMA. *Jurnal*

Normalita, 9(2):166-174. https://ejurnal.pps.ung.ac.id/index.php/JN/article/download/809/594.

Setiyaningsih, G. & Syamsudin, A. 2019. Pengembangan media big book untuk meningkatkan kemampuan literasi anak usia 5-6 tahun. *Jurnal Pendidikan dan Kebudayaan*, 9(1):19-28. https://doi.org/10.24246/j.js.2019.v9.i1.p19-28.

Sooner, S.L., Farnworth, M.J., Ward, S.J., & Whitehouse-Tedd, K.M. 2021. Conservation education: are zoo animals effective ambassadors and is there any cost to their welfare?. *Journal of Zoological and Botanical Gardens*, 2(1):41-65. https://doi.org/10.3390/jzbg2010004.

Sriyati, S., Ivana, A., & Pryandoko, D. 2021. Pengembangan perangkat pembelajaran biologi berbasis potensi lokal dadiah untuk meningkatkan keterampilan proses sains siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(2):168-180. https://doi.org/10.24815/jpsi.v9i2.18783.

Sriyati, S., Marsenda, P.H., & Hidayat, T. 2022. Pemanfaatan kearifan lokal orang rimba di Jambi melalui pengembangan bahan ajar untuk meningkatkan literasi lingkungan siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*,10(2):266-278. https://doi.org/10.24815/jpsi.v10i2.23548.

Sutarman. 2017. Pendidikan konservasi sumberdaya alam dalam pemanfaatan agroekosistem berkelanjutan. *Seminar Nasional Pendidikan*, Agustus 2017. p. 45-57.

Türkoğlu, B. 2019. Opinions of preschool teachers and pre-service teachers on environmental education and environmental awareness for sustainable development in the preschool period. *Sustainability*, 11:1-35. https://doi.org/10.3390/su11184925.

Wardani, E. & Yuanita. 2020. Pengembangan perangkat pembelajaran pendidikan lingkungan hidup berbasis kearifan lokal Bangka Belitung untuk pendidikan konservasi lingkungan pada materi flora dan fauna. *Bioedusiana: Jurnal Pendidikan Biologi*, 5(2):97-112. https://doi.org/10.37058/bioed.v5i2.2185.

Widoretno, S., Sajidan, Ramli, M., Ariyanto, J., Santosa, S., & Ayu, A.G. 2016. Penguasaan fakta, konsep, prosedur dan metakognisi melalui pertanyaan di pembelajaran problem based learning biologi. *Bioedukasi Jurnal Pendidikan Biologi*, 9(1):18-22. https://doi.org/10.20961/bioedukasi-uns.v9i1.2626.

Zuchdi & Darmiyati. 2011. *Pendidikan karakter dalam perspektif teori dan praktik*. UNY Press, Yogyakarta.

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Natural Indicators of Borax and Its Utilization in the Development of Project-Based Student Worksheets to Improve Science Process Skills

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Abstract. The foodstuff course is one of the subjects that is closely related to the context of daily life. The learning model that has been applied by lecturers has not been able to encourage students to use science process skills optimally and produce real work. The teaching materials used also have not trained students' skills and independence in solving problems of daily life. Borax is a prohibited additive in foodstuffs. This study aims to develop borax indicators from natural substances and develop project-based student worksheets to improve science process skills. The development of natural indicators of borax was carried out using the true experimental design method. Extracts of natural indicators were tested for color change in a solution of pH 5, 7, 12 and on positive and negative borax food samples. The development of student worksheets is carried out using a 4D (defining, designing, developing, and disseminating), model and is only limited to the stage through expert review. LKM that has been developed are validated by experts. The data obtained were then analyzed descriptively. The results showed that (a) extracts from secang wood and turmeric could be used as natural indicators of borax and (b) expert assessment of aspects of student worksheets obtained results in the high and very high validity ranges. The results of the development of natural indicators of borax can be used in the development of teaching materials. The developed student worksheets are suitable for limited testing.
Keywords: Natural indicators of borax, project-based learning, science process skills, student worksheets

Introduction

Learning activities should be fun, challenging, inspiring, and innovative, and encourage the students to be actively involved. Learning activities must also provide space for them to develop creativity and independence based on their interests, talents, and development. One of the recommended innovative learning models in this 21st century that has shown success in achieving learning objectives is project based learning (PjBL) (Sumarni & Kadarwati, 2020). PjBL is a model that brings students into a project to solve problems related to everyday life and produce real work (Grossman et al., 2019). PjBL is contextual and student-centered. The students can get actively involved to interact and share knowledge during the learning process (Nora et al., 2021). Thus, it is hoped that they will have a strong motivation to learn because the knowledge gained is more meaningful, useful, and appropriate for solving problems in life (Widarti et al., 2020).

The learning linked to the context of daily life can activate the students to solve more. Contextual science learning provides opportunities for them to learn more effectively so that it can support the implementation and achievement (Majid & Rohaeti, 2018). PjBL which contains context will make the learning process more enjoyable and can support the students' mastery of science process skills (KPS) (Mulyanti & Lutfi, 2022). KPS is a comprehensive, systematic, and analytical skill possessed by scientists to apply scientific methods and logical thinking (Darmaji et al., 2019). It is not only about physical involvement, but also mental-intellectual aspect (Mulyanti & Lutfi, 2022).

KPS strengthens high quality science learning so that it can develop the student's potential, minds, activeness, and sense of responsibility in building facts, concepts, and knowledge (Winarti et al., 2019; Mulyanti & Lutfi, 2022). Therefore, there must be an implementation of KPS in science learning (Safaruddin et al., 2019). Success in developing KPS depends on the learning instruction model (Mulyeni et al., 2019). Creative teaching will create more opportunities for the students to acquire more science process skills. However, KPS is most suitable to be trained through activities in the laboratory. This will help increase the student's interest in science, problem solving, communication skills, compiling and testing hypotheses, observation, and data presentation (Shana & Abulibdeh, 2020). The students should be able to master KPS, but unfortunately, their mastery level is still very low (Syazali et al., 2021).

Lecturers can use media to train the students' independence. An alternative medium to involve the students actively is a PjBL worksheet (LKM). It is prepared based on PjBL steps. LKM uses projects as activities in finding knowledge (Aliman & Mutia, 2021). Many educators so far still use textbooks and they are not familiar with worksheets. Textbooks as teaching materials have some weaknesses like containing too general materials and discussion topics (Lerian et al., 2022). Therefore, they will not be independent in learning.

The foodstuff course is elective and can be taken by fourth semester students in the Science Education Study Program of Universitas Tidar. It is closely related to the context of daily life. One of which is additives in food. Additives are deliberately added to food with for improving food quality (Ariantini, 2019). Unfortunately, there are still some prohibited additives found such as borax (Kholifah & Utomo, 2018; Napitupulu & Abadi, 2018; Suseno, 2019; Sari et al., 2020). Borax is a compound made from the element boron which is commonly used as an antifungal, antiseptic and wood preservative (Septiani & Roswien, 2018). Borax is often abused by traders to increase profits. Traders add borax in the production process so that the food products they produce can last a long time. The ease of getting borax and its low price makes borax often used by food vendors (Misbah et al., 2018). Continuous consumption of foods containing borax can endanger human health and lead to cancer (Kholifah & Utomo, 2018; Nurlailia et al., 2021).

The learning model used in this course, namely the case method, has not facilitated the students to apply KPS to the fullest. The lecturers have not developed LKM to train the students' independence in learning activities. This research aims to develop indicators of borax from natural ingredients and use them in the development of project-based LKM to improve the students' KPS.

Methods

The research consists of two stages, namely the development of natural indicators of borax and the development of LKM. A natural indicator to identify borax in food is developed using a true experimental design method. The equipment is standard glassware. The materials include borax solution, HCl solution, NaOH solution, pH 5, 7 & 12, methyl red indicator, food samples, natural ingredients (white frangipani flowers, yellow frangipani flowers, red frangipani flowers, purple cabbage, secang wood, and purple cabbage), and filter paper. The food samples test uses a random sampling technique.

The development of natural borax indicators consists of some following points. Extracts of natural ingredients (white frangipani flower, yellow and red frangipani flowers, purple cabbage, and turmeric) are ground first. Meanwhile, secang wood extract comes from a maceration process by soaking it in hot water. The indicators are then tested for color changes in a solution of pH 5, 7, and 12. The color changes of natural indicators are also tested in positive and negative borax food sample extracts. An indicator showing a clear color change in positive and negative samples of borax is selected to test borax in different samples of meatballs on the market. The meatballs that show positive borax test results are then selected using a titration method.

The development of borax indicators results in the form of extracts of natural ingredients for identifying the presence of borax in food. The steps and results obtained from the development of natural indicators will become the basis for LKM development. LKM is designed based on a project-based learning syntax and contains activities that train the students' KPS.

The research uses the 4D development model which includes the stages of defining, designing, developing, and disseminating (Thiagarajan, 1974). The developed product is a project-based LKM to improve the students' KPS. The product is tested for feasibility by three experts. The data are collected through non-test techniques with validation sheet instruments. This research is only limited to the development stage with a validator review. Next, the results of the LKM validation are calculated using Aiken's V formula according to Equation 1. Table 1 presents the validity calculation results compared with some criteria.

$$V = \frac{\Sigma s}{[n(c-1)]} \qquad (1)$$

note:
s = r-lo
r = score given by validator
lo = the lowest validity score
c = the highest validity score
n = number of validators

Table 1. Validity criteria

Interval	Criteria
0.81 – 1.00	Very high
0.61 – 0.80	High
041 – 0.60	Moderate
0.21 – 0.40	Low
0.00 – 0.20	Very low

(source: Arikunto, 2010)

Results and Discussion

Development of Borax Natural Indicators

The indicators' color changes in pH 2, 7, and 12 solutions are used to determine the color change trajectory of each indicator in acidic, basic, and neutral solutions. Table 2 shows the color changes.

Table 2. Color changes of indicators in acidic, basic, and neutral solutions

Natural indicator	pH=2	pH=7	pH=12
White frangipani flower	Brown	Brown	Brown
Yellow frangipani flower	Colorless	Yellow	Yellow
Red frangipani	Brownish-yellow	Brownish-yellow	Brownish-yellow
Purple cabbage	Pink	Purple	Green
Secang wood	Yellow	Orange	Deep pink
Turmeric	Yellow	Yellow	Yellowish-brown

Table 2 shows that white and red frangipanis do not have a clear color change in acidic and basic solutions. Meanwhile, yellow frangipani, purple cabbage, secang wood, and turmeric have sharp color changes in acidic and alkaline solutions. A substance that can be used as an indicator is a weak organic acid or base which has a different color between the ionized and non-ionized forms (Chang, 2003). Natural indicators are for testing positive and negative borax food samples. The test samples include meatballs, wet noodles, and siomay. Borax and distilled water solutions will be the controls. Table 3 presents the results of the indicators' color changes in the positive and negative borax sample extracts.

Table 3. Color changes of indicators in positive and negative samples of borax

Sample	White frangipani	Yellow frangipani	Red frangipani	Purple cabbage	*Secang* wood	Turmeric
Borax solution	Brown	Yellow	Brownish-yellow	Bluish purple	Pink	Yellowish-brown
Aquades	Brown	Yellow	Brownish-yellow	Purple	Orange	Yellow
Meatball 1*	Brown	Yellow	Brownish-yellow	Bluish purple	Pink	Yellowish-brown
Meatball 2**	Brown	Yellow	Brownish-yellow	Purple	Orange	Yellow
Noodle 1*	Brown	Yellow	Brownish-yellow	Bluish purple	Pink	Yellowish-brown
Noodle 2**	Brown	Yellow	Brownish-yellow	Purple	Orange	Yellow
Siomay 1*	Brown	Yellow	Brownish-yellow	Bluish purple	Pink	Yellowish-brown
Siomay 2**	Brown	Yellow	Brownish-yellow	Purple	Orange	Yellow

* Sample contains borax; ** Sample does not contain borax

Table 3 shows that positive samples of borax will follow the trend of the color change of the borax solution. Meanwhile, the negative ones follow the trend of the color change of the distilled water. The indicators of secang wood and turmeric show clear color differences in positive and negative samples. White, yellow, and red frangipanis do not show clear color differences. Purple cabbage also does not perform a sharp color change in positive and negative borax samples, although Table 1 shows a sharp color difference in an acidic solution pH = 2 (pink) and a basic solution pH = 12 (green). This is because borax is a weak base. Borax (Mr=381.43 gram/mol) has a boron content of 11.34% and a pH ranging from 9.15 to 9.20 (Wahyuni, 2020). The color changes of the purple cabbage indicator in positive (bluish purple) and negative (purple) borax samples are difficult to distinguish by sight.

Secang wood and turmeric extracts may function as indicators of borax in food samples. Secang wood will change color to orange in negative samples of borax and pink in positive ones. The color change is following Purbaningtias et al. (2017). Secang wood extract contains a brazilin composite consisting of 3-O-methylbrazilin, brazilin, and brazilin compounds, with brazilin as the main component (de Oliveira et al., 2002). These compounds cause changes in the color of secang wood extract in different pH solutions. Meanwhile, turmeric contains the most important component, namely curcumin (50-60%). Curcumin is stable in acidic conditions, but it is not in alkaline conditions. Turmeric extract is yellow in the pH range of 1-7, and at a pH level higher than 7.5, there will be a brownish-red color change. Curcumin is degraded into furolilmetan (4-hydroxy-3-methoxynamyl-methane) and ferulic acid (4-hydroxy-3-methoxynamitic acid) in neutral and alkaline states (Stankovic, 2004).

Natural indicators from *secang* wood extract and turmeric are used to test for borax in various samples of meatballs on the market. Table 4 presents the complete test results.

Table 4. Test results for borax in various samples of meatballs on the market using natural indicators from extracts of *secang* wood and turmeric

Sample	*Secang* wood	Turmeric	Note
Meatball 1	Pink	Yellowish-brown	+
Meatball 2	Pink	Yellowish-brown	+
Meatball 3	Orange	Yellow	-
Meatball 4	Orange	Yellow	-

Table 4 shows that two of the four meatball samples contain borax. This is following the results of previous studies which found borax in meatballs sold in the market (Suntaka, 2015; Napitupulu & Abadi, 2018; Suseno, 2019; Sari et al., 2020). Borax can kill microorganisms, so it is widely used to inhibit the growth of mold and mildew in the textile industry. Also, borax works as an insecticide in the paper, glass, plastic, and leather industries (Alsuhendra, 2013). Borax has been banned as a food additive. It can accumulate in human body cells. Its harmful effects on health will not arise directly (Tubagus, 2013). However, at high levels, it can cause poisoning to death (Alsuhendra, 2013). The borax content in the meatball samples is then determined using the titration method according to equation 2.

$$Na_2B_4O_7.10H_2O_{(aq)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + 4H_3BO_{3(aq)} + 5H_2O_{(aq)} \quad (2)$$

Table 5. Borax levels in meatball samples

Sample	Volume HCl 0,05 M (mL)				Borax level (%)
	V_1	V_2	V_3	V rata-rata	
Meatball 1	0.7	0.7	0.8	0.73	0.28
Meatball 2	1.2	1.1	1.1	1.13	0.43

Table 5 presents the borax levels in the meatball samples. The results are similar to Suseno (2019) and describe that prodecer use borax without a definite standard or dosage. This is certainly dangerous for the health of consumers.

Development of LKM

The products resulting from the development of borax indicators are used for the development of LKM in the foodstuff course. LKM is designed based on project-based learning steps and includes some activities that train science process skills. The research findings are explained based on the stages of the research model, namely define, design, and development.

Define

The first stage in product research development is "define". The Foodstuffs course is an elective for Semester IV students of the Science Education Study Program of Universitas Tidar. The basic problem in the implementation of learning for this course is that the learning steps do not train the KPS ye. There are also no worksheets that support the improvement of KPS. The implemented learning (case method) has not facilitated the students to hone their KPS. The course material developed is food additives. It is expected that the students can master the concept of additives. The expected final ability after attending this course is that they can identify harmful preservatives in food, identify natural ingredients as the indicators of borax, and determine levels of borax in food. Therefore, it is necessary to develop project-based LKM to enhance KPS.

Design

It is the designing stage of LKM based on some criteria adapted from the Ministry of National Education (2008) which includes (1) title, subject, semester, and location, (2) study guide, (3) competencies; (4) indicators; (5) supporting information, (6) work steps, and (7) assessment. The developed LKM also meets the didactic, construction, and technical requirements (Darmojo, 1992). LKM is structured based on PjBL learning steps according to The George Lucas Educational Foundation (2005), namely basic questions, preparing project designs, preparing work plans, implementing and monitoring projects, testing the results, evaluating, and reflecting. LKM also contains activities that train KPS which include basic and integrated skills based on the (American Association for the Advancement of Science, 1966).

Development

The designed LKM is then developed. The appearance of the developed LKM is presented in Figure 1.

Figure 1. Visual representation of the developed LKM

The developed LKM are validated by experts and Table 6 presents the results. The LKM’s assessment aspects (didactic, construction, and technical) consist of high and very high validity. The didactic aspect relates to LKM being able to facilitate all students' abilities in discovering concepts. The construction aspect relates to the clarity of the material in the LKM, the choice of words, sentence structure, and the use of LKM language. While the technical aspects concern the selection of the type and size of the font, image and appearance of the LKM. The results of expert validation have fulfilled for further testing. Worksheets as a type of teaching material function as a learning tool for educators and students (Lerian et al., 2022). The use of LKM should be able to overcome the limitations of textbooks as the most common learning source. These limitations include a general textbook discussion by presenting a lot of materials, a little enrichment of practice questions, and not yet leading students to find concepts (Lerian et al., 2022). Meanwhile, the worksheet contains activities that students must do in forming their basic skills and understanding according to indicators of learning outcomes (Susilawati et al., 2020). The suggestions from the validator are used as LKM’s improvements. Table 7 displays the suggestions from validators for the LKM’s improvements.

Table 6. The results of the LKM based on the borax natural indicator project

No		Valued aspect	V Aiken's	Criteria
1		Didactic		
	a	CPMK and expected final capabilities are formulated	0.92	Very high
	b	LKM is directed at efforts to realize the project	0.92	Very high
	c	LKM is directed at trying to find concepts	0.92	Very high
	d	LKPD components help develop cognitive abilities	0.83	Very high
	e	LKM activities train science process skills	0.92	Very high
2		Construction		
	a	LKM identity describes the profile of students	0.92	Very high
	b	Project completion starts from a simple to a complex stage	0.92	Very high
	c	The sentence structure used is accompanied by operational verbs whose achievement can be measured	0.75	High
	d	The use of language is following the psychological development of students	0.75	High
	e	LKM uses references that support teaching materials	0.92	Very high
	f	LKM uses effective sentences	0.75	High
3		Technical		
	a	The title of the LKM describes its contents	1	Very high
	b	Readability of writing and typeface used	0.92	Very high
	c	Tables and writings are arranged proportionally	0.92	Very high
	d	LKM appearance or layout	0.8	High

Table 7. LKM improvement based on validation results

Validation source	Before improvement	After improvement
Expert lecturer	The introduction of the problem does not include differences in foods that contain and do not contain borax	The introduction of the problem has included differences in foods that contain and do not contain borax
	Questions on problem recognition: a. Why is food mixed with borax? b. What are the dangers of borax for health?	Questions on problem recognition: a. Why can't borax be added to food? b. Deleted
	It does not include references to observation tables in concluding	It has included references to observation tables in concluding

Validation source	Before improvement	After improvement
	natural materials that can be used as borax indicators	natural materials that can be used as borax indicators
	Some sentences use the type and size of letters that are not uniform	Sentences have used the font type and font size is not uniform
	Some words have the wrong spelling	The wrong spelling of words has been fixed

Table 7 shows that there is only a slight correction from the validator. The LKM is then corrected based on the suggestions, so that the content in the LKM is more interesting and better at encouraging students to actively construct their own knowledge. This is in accordance with the statement of Anjarwati et al. (2018) that LKMs that are designed systematically and attractively are able to help students learn more actively and with focus. MFIs can be designed by containing problems in everyday life related to material concepts and their solutions can be carried out through project assignments (Sari & Wulanda, 2019). The developed LKM contains borax problem-solving activities by compiling a project. The following sections explain the activities in detail.

Basic questions

The learning starts with associating learning material with real and relevant problems (the use of borax as a food additive). The LKM contains basic questions such as (a) why can't borax be added to food? and (b) how do we distinguish foods that contain borax? These questions encourage the students to conduct an in-depth investigation of the topic.

Designing a project

Project planning is done collaboratively between the lecturers and the students. It aims to make the students a sense of ownership and responsibility for the project. Planning contains some steps to answer the fundamental questions asked before. They plan a project in the form of a natural indicator to test borax in food. Some activities in preparing the project design contained in the LKM are (a) writing research hypotheses, (b) writing research variables to obtain natural borax indicator products, (c) writing tools, materials, and work methods, and (d) compiling observation tables.

Preparing work plan

The lecturers and the students jointly arrange a series of activities in completing the project. The students write down the agreed schedule in the project implementation table listed on the LKM. Several activities in the work plan include (a) compiling a timeline and deadline for project completion, (b) encouraging the students to plan new ways of working, (c) directing the students if they develop ways of working that are not related to the project, and (d) asking the students about the selection of work methods (The George Lucas Educational Foundation, 2005)

Project implementation and monitoring

The students carry out the project according to the design and schedule that have been set. Each activity embodies the project and the progress. The results obtained are recorded at the LKM. Thus, the LKM functions to record the students' activities. Meanwhile, the lecturers are responsible for monitoring their progress in completing the project. The George Lucas Educational Foundation (2005) stated that in monitoring activities, the lecturers act as mentors and facilitators for the students.

Result testing

The results testing activities contained in the LKM consist of (a) discussing projects that have been obtained, (b) presenting the results of the discussions, and (c) writing reports in the form of scientific articles. Jeenthong, et al. (2014) stated that science learning should move towards its application in scientific work. Therefore, it is not only oriented toward remembering concepts. The George Lucas Educational Foundation (2005) explained that the results test helps the lecturers in measuring the level of standard achievement, providing feedback on student understanding and assessing the progress they have achieved, and evaluating the materials to plan further learning strategies.

Evaluation and reflection

The lecturers and the students carry out evaluations and reflections at the end of the learning process. The evaluation and reflection activities listed in the LKM include (a) explaining the advantages and disadvantages of natural materials as borax indicators, (b) drawing conclusions from the project activities that have been carried out, and (c) explaining the experience that has been gained. During the evaluation, the discussion aims to improve performance to obtain new findings as a solution to the problems posed at the beginning of learning (The George Lucas Educational Foundation, 2005). The evaluation and reflection stages should be able to culminate in a finding regarding natural ingredients used to identify borax in food. The selection of natural materials as indicators of borax must consider their advantages and disadvantages. Thus, the findings can solve the problem of how to identify borax in food.

PjBL has been known to be able to facilitate students to use KPS (Nuraini & Waluyo, 2021). To achieve KPS mastery, students need to be guided by using LKM (Rahmawati et al., 2022). The series of discovery activities contained in the LKM facilitate the students to use different KPS. Table 8 shows the KPS highlighted from LKM. LKM should be developed to encourage the student's independence in solving real problems and improving KPS. This is following Putra et al. (2015) and Citradevi et al. (2017), that worksheets can be used to improve KPS in active learning in the classroom through project activities and practicum. Besides, the use of worksheets in the learning process can streamline the learning process, and encourage, facilitate and help participants to learn actively and better (Susilawati et al., 2020). Science process skills are vital in learning science because learning will consider the process and final result (Fikriyah & Gani, 2015).

The developed LKM contains activities to train basic and integrated science process skills as shown in Table 8. The basic KPS contained are observing, measuring, concluding, predicting, classifying, communicating. While the integrated KPS includes data interpretation, formulating hypotheses, and designing experiments. Basic skills are the foundation for mastering more complex integrated skills (Bulent, 2015; Darmaji et al., 2019). Students must have basic skills first in order to be able to master integrated skills (Turiman et al., 2012). For example, students who do not master basic observing skills, these students will not get information and problems to be solved (Darmaji et al., 2019). Observation skills can encourage other skills such as inferring, predicting, and communicating (Rezba et al., 2003). Thus, if students do not fully master KPS, it will hinder their mastery of higher abilities (Darmaji et al., 2019). The weakness of the developed LKM is that it does not yet contain the skill activities to control variables and define variables operationally. Therefore, further research is expected to be able to develop LKM that facilitate students to develop all KPS.

Table 8. KPS contained in LKM

Nu	Aspect of KPS	Students' Activities
1	Observing	Observing and collecting data on the color change of natural indicators in the test sample extracts
2	Measuring	Weighing the ingredients, measure the volume of the solution
3	Concluding	a. Concluding natural ingredients that can be used as indicators of borax b. Concluding food samples containing borax
4	Predicting	Using natural indicator color change trends to determine borax-containing food samples
5	Classifying	a. Recording the observation data according to the observation table b. Classifying natural materials that can and cannot be used as indicators c. Classifying positive and negative borax food samples
6	Communicating	a. Explaining the results of the project, namely natural materials that can be used as borax indicators b. Describing empirical data on quantitative tests of borax in food c. Preparing reports on project results in the form of articles systematically
7	Data interpretation	a. Finding the trend of the color change of natural indicators in food extracts positive and negative borax b. Interpreting the HCl volume data required for titration with borax levels in food samples
8	Formulating hypotheses	Formulating a natural product investigation hypothesis that can be used as an indicator of borax
9	Designing experiments	Designing an experiment to determine natural materials that can be used as borax indicators

LKM contains activities to train KPS as shown in Table 8. By using LKM, students directly practice science process skills. Kurniawan et al. (2022) stated that students' KPS would increase if they were given the opportunity to practice these skills. Meanwhile, students' KPS is needed to build students' concepts and understanding (Farida et al., 2020). Thus the content of activities in the LKM will greatly determine the quality of learning and mastery of the competencies of students. The LKM developed has the advantage that students design projects using natural materials and materials around them. Learning by utilizing materials around and natural materials will not reduce the content of learning. Students easily get these materials and consider science close to everyday life (Mastura et al., 2017).

Conclusion

The research findings conclude that extracts of secang wood and turmeric can be natural indicators of borax contents in food. LKM is developed based on research on the development of natural indicators of borax. It is structured based on the PjBL syntax and contains activities that can train the students' KPS. Assessments by experts on the didactic, construction, and technical aspects of the LKM show high and very high validity levels. Therefore, LKM is eligible for testing to the next stage for limited trials.

References

Aliman, M. & Mutia, T. 2021. The effect of digital eco-learning in student worksheet flipbook to environmental project literacy and pedagogic competency. *Journal of Technology and Science Education*, 11(2):357-370. http://dx.doi.org/10.3926/ jotse.1175.

Alsuhendra, R. 2013. Bahan toksik dalam makanan. Bandung: PT. Remaja Rosdakarya.

American Association for the Advancement of Science. 1966. Science: A process approach. American Association for the Advancement of Science.

Anjarwati, P.G.P., Sajidan, S., & Prayitno, B.A. 2018. Problem-based learning module of environmental changes to enhance students creative thinking skill. *Biosaintifika: Journal of Biology & Biology Education*, 10(2):313-319. https://doi.org/10.15294/biosaintifika.v10i2.12598.

Ariantini, N.S. 2019. Analisis kadar zat aditif pada minuman sirup rasa marquisa. *International Journal of Applied Chemistry Research*, 1(2):47-51. https://doi.org/10.23887/ijacr.v1i2.28735.

Arikunto, S. 2010. Prosedur penelitian. Jakarta: Rineka Cipta.

Bulent, A.Y.D.O.G.D.U. 2015. The investigation of science process skills of science teachers in terms of some variables. *Educational Research and Reviews*, 10(5):582-594.

Chang, R. 2003. General chemistry: The essential concepts. Jakarta: Erlangga.

Citradevi, C.P., Widiyatmoko, A., & Khusniati, M. 2017. The effectiveness of project based learning (PjBL) worksheet to improve science process skill for seven graders of junior high school in the topic of environmental pollution. *Unnes Science Education Journal*, 6(3):1677-1685. https://doi.org/10.15294/usej.v6i3.20359.

Darmaji, D., Kurniawan, D.A., & Irdianti, I. 2019. Physics education students' science process skills. *International Journal of Evaluation and Research in Education*, 8(2):293-298. http://doi.org/10.11591/ijere.v8i2.16401.

Darmojo, H. 1992. Pendidikan IPA. Jakarta: Departemen Pendidikan dan Kebudayaan Direktorat Pendidikan Tinggi Profesi *Pendidik* dan Tenaga Kependidikan.

de Oliveira, L.F., Edwards, H.G., Velozo, E.S., & Nesbitt, M. 2002. Vibrational spectroscopic study of brazilin and brazilein, the main constituents of brazilwood from Brazil. *Vibrational Spectroscopy*, 28(2):243-249. https://doi.org/10.1016/S0924-2031(01)00138-2.

Farida, I., Zahra, R. R., & Irwansyah, F. S. 2020. Experiment optimization on the reaction rate determination and its implementation in chemistry learning to develop science process skills. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(1):67-77. https://doi.org/10.24815/jpsi.v8i1.15608.

Fikriyah, M. & Gani, A.A. 2015. Model pembelajaran berbasis proyek (project based learning) disertai media audio-visual dalam pembelajaran fisika di SMAN 4 Jember. *Jurnal Pembelajaran Fisika*, 4(2):181-186. https://jurnal.unej.ac.id/index.php/JPF/article/view/2165.

Grossman, P., Dean, C.G.P., Kavanagh, S.S., & Herrmann, Z. 2019. Preparing teachers for project-based teaching. *Phi Delta Kappan*, 100(7):43-48. https://doi.org/10.1177/003172171984133.

Jeenthong, T., Ruenwongsa, P., & Sriwattanarothai, N. 2014. Promoting integrated science process skills through betta-live science laboratory. *Procedia-Social and Behavioral Sciences*, 116:3292-3296. https://doi.org/10.1016/j.sbspro.2014.01.750.

Kholifah, S. & Utomo, D. 2018. Uji boraks dan formalin pada jajanan disekitar Universitas Yudharta Pasuruan. *Teknologi Pangan: Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian*, 9(1):10-19. https://doi.org/10.35891/tp.v9i1.933.

Kurniawan, F., Djukri, D., & Haka, N.B. 2022. The predict-observe-explain model: is it effective to improve science process skills?. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 10(4):803-815. https://doi.org/10.24815/jpsi.v10i4.26172.

Lerian, N., Erlina, E., Harun, A.I., Saputra, R., & Sasri, R. 2022. Pengembangan LKPD disertai hybridization kit berbasis discovery learning pada materi bentuk molekul dengan teori hibridisasi untuk pembelajaran siswa kelas X. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(4):669-693. https://doi.org/ 10.24815/jpsi.v10i4.25753.

Majid, A.N. & Rohaeti, E. 2018. The effect of context-based chemistry learning on student achievement and attitude. *American Journal of Educational Research*, 6(6):836-839. https://doi.org/10.12691/education-6-6-37.

Mastura, M., Mauliza, M., & Nurhafidhah, N. 2017. Desain penuntun praktikum kimia berbasis bahan alam. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 1(2):203-212. https://doi.org/10.24815/jipi.v1i2.9695.

Misbah, S.R., Darmayani, S., & Nasir, N. 2018. Analisis kandungan boraks pada bakso yang dijual di Anduonohu kota Kendari Sulawesi Tenggara. *Jurnal Kesehatan Manarang*, 3(2), 81-85. https://doi.org/10.33490/jkm.v3i2.41.

Mulyeni, T., Jamaris, M., & Supriyati, Y. 2019. Improving basic science process skills through inquiry-based approach in learning science for early elementary students. *Journal of Turkish Science Education*, 16(2):187-201. https://doi.org/10.12973/tused.10274a.

Napitupulu, L.H. & Abadi, H. 2018. Analisis zat berbahaya boraks dan rhodamin b pada jajanan bakso bakar yang dijual dibeberapa Sekolah Dasar di Kecamatan Medan Denai. *Jurnal Kesehatan Global*, 1(1):21-27. https://doi.org/10.33085/jkg.v1i1.3942

Nora, R., Fitriawan, H., & Yulianti, D. 2021. Project-based online learning effectiveness in improving the skills of addressing contextual problems in the covid-19 pandemic. *American Research Journal of Humanities Social Science (ARJHSS)*, 4(5):1-5. https://www.arjhss.com/wp-content/uploads/2021/05/A450105.pdf.

Nuraini, N. & Waluyo, E. 2021. Pengembangan desain instruksional model project based learning terintegrasi keterampilan proses sains untuk meningkatkan literasi sains. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 5(1):101-111. https://doi.org/10.24815/jipi.v5i1.20145.

Nurlailia, A., Sulistyorini, L., & Puspikawati, S. I. 2021. Analisis kualitatif kandungan boraks pada makanan di wilayah Kota Banyuwangi. *Medika Gizi Kesmas*, 10:254-260.

Purbaningtias, T.E., Lestari, I.D., Wiyantoko, B., Kurniawati, P., & Sriadryani, D. 2017. Utilization of natural indicators for borax identification in the Indonesian tofu. *AIP Conference Proceedings*, 1823(1):1-7. https://doi.org/10.1063/1.4978130.

Putra, N.A.R., Abdurrahman, A., & Suana, W. 2015. Pengaruh keterampilan proses sains dan sikap ilmiah terhadap pemahaman konsep IPA siswa SMP. *Jurnal Pembelajaran Fisika*, 3(4):33-42. http://jurnal.fkip.unila.ac.id/index.php/JPF/article/view/8861.

Mulyanti, A.A. & Lutfi, E. 2022. Development of guided project based learning (g-PjBL) integrated contextual teaching and learning (i-CTL) models to im-prove science process skills and strengthen characters of high school students/SMA. *Central Asian Journal of Theoretical and Applied Science,* 3(3):63-69. https://doi.org/10.17605/OSF.IO/UY8GA.

Rahmawati, T., Suhanda, H., Sabilla, F.I.A., & Suryatna, A. 2022. Implementation of practicum worksheets based on guided inquiry on the topic of colloids to improve students' science process skills. *JIPI (Jurnal IPA & Pembelajaran IPA*), 6(4):409-422. https://doi.org/10.24815/jipi.v6i4.28354.

Rezba, R.J., Sprague, C., & Fiel, R. 2003. *Learning and assessing science process skills*. Kendall Hunt.

Safaruddin, S., Ibrahim, N., Juhaeni, J., Harmilawati, H., & Qadrianti, L. 2020. The effect of project-based learning assisted by electronic media on learning motivation and science process skills. *Journal of Innovation in Educational and Cultural Research*, 1(1):22-29. https://doi.org/10.46843/jiecr.v1i1.5.

Sari, M.M., Nurmansyah, J., & Supriati, R. 2020. Uji kandungan boraks pada bakso di Kecamatan Muara Bangkahulu Kota Bengkulu. *Konservasi Hayati*, 16(1):39-45. https://doi.org/10.33369/hayati.v16i1.11568.

Sari, D.S. & Wulanda, M.N. 2019. Pengembangan lembar kerja mahasiswa berbasis proyek dalam meningkatkan kemampuan berfikir kreatif mahasiswa. *Natural: Jurnal Ilmiah Pendidikan IPA*, 6(1):20-33. https://doi.org/10.30738/natural.v6i1.4073.

Septiani, T. & Roswien, A.P. 2018. Analisis kualitatif kandungan boraks pada bahan pangan daging olahan dan identifikasi sumber boron dengan FTIR–ATR. *Indonesia Journal of Halal*, 1(1):48-52. https://doi.org/10.14710/halal.v1i1.3403.

Stankovic, I. 2004. Curcumin: chemical and technical assessment (CTA). *JECFA, Rome*, *8*.

Sumarni, W. & Kadarwati, S. 2020. Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, 9(1):11-21. https://doi.org/10.15294/jpii.v9i1.21754.

Suntaka, D.F.A. 2015. Analisis kandungan formalin dan boraks pada bakso yang disajikan kios bakso permanen pada beberapa tempat di Kota Bitung Tahun 2014. *Kesmas: Jurnal Kesehatan Masyarakat Universitas Sam Ratulangi*, 4(1):39-45.

Syazali, M., Rahmatih, A.N., & Nursaptini, N. 2021. Profil keterampilan proses sains mahasiswa melalui implementasi SPADA Unram. *Jurnal Pijar MIPA*, 16(1):103-112. https://doi.org/10.29303/jpm.v16i1.2290.

Suseno, D. 2019. Analisis kualitatif dan kuantitatif kandungan boraks pada bakso menggunakan kertas turmerik, FT–IR spektrometer dan spektrofotometer Uv-Vis. *Indonesia Journal of Halal*, 2(1):1-9. https://doi.org/10.14710/halal.v2i1.4968.

Shana, Z. & Abulibdeh, E.S. 2020. Science practical work and its impact on high students' academic achievement. *Journal of Technology and Science Education*, 10(2)L199-215. https://doi.org/10.3926/jotse.888.

Susilawati, E., Agustinasari, A., Samsudin, A., & Siahaan, P. 2020. Analisis tingkat keterampilan berpikir kritis siswa SMA. *Jurnal Pendidikan Fisika Dan Teknologi*, 6(1):11-16. https://doi.org/10.29303/jpft.v6i1.1453.

The George Lucas Educational Foundation. 2005. Instructional Module Project Based Learning. Diakses pada tanggal 1 September 2022 dari http://www.edutopia.org/modules/PBL/whatpbl.php.

Thiagarajan, S. 1974. Instructional Development for Teacher of Exceptional. *Children. Bloomington: Indiana University. www. eric. ed. gov/ERICWebPortal/recordDetail*. Treagust, D. F. 2004. An investigation of science teaching practices in Indonesian rural secondary schools. *Research in Science Education*, 34(4):455-474.

Tubagus, I. 2013. Identifikasi dan penetapan kadar boraks dalam bakso jajanan di Kota Manado. *Pharmacon*, 2(4):142-148. https://ejournal.unsrat.ac.id/v3/index.php/pharmacon/article/view/3104.

Turiman, P., Omar, J., Daud, A.M., & Osman, K. 2012. Fostering the 21st century skills through scientific literacy and science process skills. *Procedia-Social and Behavioral Sciences,* 59:110-116. https://doi.org/10.1016/j.sbspro.2012.09.253.

Wahyuni, R.S. 2020. Uji kualitas ekstrak kulit secang (*Caesalpinia sappan* L.) sebagai kandidat borax rapid test kit. *Thesis*, Universitas Islam Indonesia, Indonesia. https://dspace.uii.ac.id/123456789/28284.

Widarti, H.R., Rokhim, D.A., & Syafruddin, A.B. 2020. The development of electrolysis cell teaching material based on stem-pjbl approach assisted by learning video: A need analysis. *Jurnal Pendidikan IPA Indonesia*, 9(3):309-318. https://doi.org/10.15294/jpii.v9i3.25199.

Winarti, A., Yuanita, L., & Nur, M. 2019. The effectiveness of multiple intelligences based teaching strategy in enhancing the multiple intelligences and science process skills of Junior High School students. *Journal of Technology and Science Education*, 9(2):122-135. http://dx.doi.org/10.3926/jotse.404.

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Blended Learning Program Based on Multiple Representations: Needs Analysis to Stimulate Complex Problem Solving and Reduce Learning Loss

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Abstract. Various complex problems arise along with the increasingly massive development of science and technology in the 21st century. Special skills are needed to survive and adapt to a complex environment and demand various problems to be solved. This study aimed to determine the need for developing multiple representations-based blended learning programs to stimulate complex problem-solving (CPS) and reduce learning loss. This study uses a qualitative descriptive method to provide an overview of the implementation of CPS in high schools and the learning loss during lessons during the Covid-19 pandemic. This research was conducted in July 2022. The data source was obtained using a non-test technique in the form of an open questionnaire. The subjects in this study were 13 physics teachers and 25 students spread across 4th provinces in Indonesia, including Lampung, DIY, Central Java and West Java. The data analysis technique is the Milles & Hubberman analysis technique carried out continuously until the data is saturated. Data analysis involves three steps, data reduction, data presentation, and concluding/verification. Study result show that CPS has yet to be fully implemented in physics learning in high schools. Learning during the Covid-19 pandemic was ineffective and maximal, which resulted in most students experiencing setbacks in learning and a decrease in academic progress (learning loss). Therefore, developing a blended learning program based on multiple representations is necessary to stimulate complex problem-solving and reduce learning loss.
Keywords: Blended Learning Programs, Multiple Representations, Complex Problem Solving, Learning Loss

Introduction

The massive development of science and technology has made the barriers between areas of life increasingly thin. In the 21st century, the world is faced with an increasingly complex environment that requires solving various problems (Fischer et al., 2012; Schefer-Wenzl & Miladinovic, 2019). The problems encountered sometimes require more than one solution and are related to other problems, so special skills are needed to solve them. Complex problem solving (CPS) is considered an increasingly important skill in both professional and personal life (Binkley et al., 2012; Funke et al., 2018) that everyone must possess to survive in the 21st century (Dörner & Funke, 2017). Complex problems can be characterized as unclear problems, both the root causes, the purpose of solving them and how to solve them, so that often the solutions carried out can involve other unexpected variables that are not even related to the problem. The characteristics of a complex system are 1). Complex problem situations; 2). connectivity and dependency between the variables involved; 3). dynamic situation; and 4). variables are not transparent. In a situation, goals lead to conflicting goals at various levels (Fischer et al., 2012). Looking at the CPS in more detailedly and following a functionalist approach, creating a decent representation can increase information search and find concrete solutions (Vollmeyer et al., 1996). According to behavioural theory by Dörner (1986), complex problem solvers must (1) collect information systematically, (2) integrate the most relevant information, (3) know how to build mental models, (4) make and evaluate forecasts plans and decisions and (5) set and evaluate goals. Various cognitive processes are involved in solving complex problems (Eichmann et al., 2019c). CPS is critical to succeeding in a constantly changing environment with sometimes unknown issues (Graesser et al., 2018; Greiff & Fischer, 2013). Gathering information about critical CPS processes is the basis for making students better problem solvers and preparing for future challenges (Eichmann et al., 2019a).

The close relationship between CPS in all aspects of life makes it essential to practice this skill, especially during the learning process. However, research on this topic has so far been limited. Several previous CPS studies have led to evaluation (Bhagat & Spector, 2017; A. Graesser et al., 2017; Greiff & Fischer, 2013; Herde et al., 2016; Molnár et al., 2017), exploration (Dörner & Funke, 2017; Eichmann et al., 2020), and planning (Eichmann et al., 2019b). Schefer-Wenzl & Miladinovic (2019) designed a blended learning curriculum focusing on didactic methods in teaching CPS to engineering students. Unfortunately, the CPS development design is still limited to engineering with software integration and cannot be applied to high school learning, such as physics. Physics is a subject that is closely related to life. Physics makes a significant contribution to the development of technology in the world. Physicists continue to innovate to solve various existing complex problems. Seeing this fact, CPS skills need to be trained during learning at school. Direct current electricity is one of the physics materials that can stimulate CPS skills. Direct current electricity is very closely related to everyday life and requires various problems to be solved. Another problem faced is students who tend to solve direct current electricity problems, not in a systematic, random, and guessing manner (Citra et al., 2021). This shows that students' CPS ability on this material is still low.

Apart from that, the physics learning process also experienced various limitations, especially during the covid-19 pandemic. School closures during the covid-19 pandemic have deprived students of the education they need (Aucejo et al., 2020; Wyse et al., 2020). This prompted the government to issue policies to implement distance learning, which impacted students who lost many learning opportunities and experienced learning loss (Tomasik et al., 2021). Learning loss is defined as the absence of optimal learning processes in schools (Li et al., 2020). Learning loss refers to a general or specific loss of knowledge and skills or a reduction in academic progress, usually caused by extended gaps or discontinuities in education (Kurniawan & Budiyono, 2021). Data from the United States suggests that students of colour may lose 3 to 5 months of study time, while white students lose only 1 to 3 months (Dorn et al., 2020). The research results in Ghana show that within three months, there is an average learning loss of 66% of the previous learning gain during the transition period (Sabates et al., 2021). According to a World Bank study, Indonesian students have lost 0.9 years or around ten months of school learning since the beginning of 2020 due to the covid-19 pandemic (Yarrow et al., 2020). A survey of teachers also found that students experienced learning loss characterized by skipping assignments and lower test scores (Chen et al., 2021). These effects can affect the financial well-being of some students for the rest of their lives.

Physics learning during the pandemic also experienced significant obstacles. The characteristics of the topics discussed in physics are complex and consist of various representations, making it difficult for students to understand the material, especially if learning is only done online. One topic that requires special attention because of the many levels of difficulty experienced by students is direct current electricity. On this topic, many students experience learning difficulties in almost every sub-topic, namely electric current strength, ohm's law, conductive resistance, Kirchoff's law, and energy and electric power. These learning difficulties are caused by low mastery of concepts, weak students' mathematical calculation skills, lack of ability to convert units (Wahyuni & Handhika, 2019), and lack of variety of media and learning methods (Nofitasari & Sihombing, 2017).

Several studies offer solutions to overcome learning loss, one of which is the Heroe online learning model (Kurniawan & Budiyono, 2021). However, this model is still limited to a case study on a limited subject and has not been tested empirically involving more subjects, including Physics. Another solution offered is the gamification method, which positively impacts learning (Hidayat et al., 2021). However, the use of this gamification method is mostly applied to learning in elementary schools (Purniasih et al., 2020; Putrama & Suyasa, 2020; Qodr, 2020; Tangkui & Keong, 2020) and students with special needs (Pradnyana et al., 2020). No research specifically discusses the application of this method in learning physics in secondary schools. In addition, the use of multiple representations (MRs) in blended learning programs is seen as improving CPS skills and reducing learning loss. Blended learning is defined as a learning approach that combines face-to-face learning in class with asynchronous and or synchronous online learning (Wu et al., 2010). An effective Blended Learning environment includes face-to-face interaction in class, online content, assignments, announcements, synchronous conversations, asynchronous forum discussions, and online chat (Calderón et al., 2021). Learning with MRs means using two or more external representations simultaneously (Ainsworth, 2006). MRs allow educators/teachers to display various concepts using verbal methods, pictures, graphs, diagrams, tables, or mathematical equations simultaneously (Abdurrahman et al., 2019). Research on learning with MRs shows that student performance improves when interacting with appropriate representations (Fatmaryanti & Nugraha, 2019; Lucas & Lewis, 2019; Munfaridah et al., 2021). Some researchers (Citra et al., 2020; Fatmaryanti & Nugraha, 2019; Opfermann et al., 2017) have also found that external MRs can help students understand concepts and help them solve problems.

Physics lessons, one of which is the topic of direct current electricity, often use more than one representation, for example, in the form of text, mathematical equations, graphs/diagrams, pictures, verbal or 4-dimensional representations in the form of teaching aids in explaining the concepts. The use of MRs in physics learning is a particular need for students to learn about the given concepts and mediate their cognitive processes in solving physics problems (Kohl & Finkelstein, 2017). This is also an alternative to facilitate the diverse learning needs of students, especially in studying physics. In addition, the blended environment provides firm support and creates opportunities for students to be actively involved in shaping their learning (Montgomery et al., 2019), it can also encourage their involvement in collaborative discussions and motivate them to perform assignments (Suana et al., 2019). Through appropriate learning programs, students will be able to develop their CPS skills and minimize the effects of loss in learning. Thus, the purpose of this research is to find out the need for the development of a blended learning program based on multiple representations. The findings also provide a glimpse into the profile of CPS implementation in secondary schools. The results of this research are expected to be the basis for developing multiple representations-based blended learning programs to facilitate complex problem-solving skills and reduce learning loss.

Methods

This study uses a qualitative descriptive method to provide an overview of the implementation of CPS in high schools and the learning loss during lessons during the Covid-19 pandemic. Descriptive research is collecting information based on facts found in the field (Arikunto, 2019). Qualitative research helps us to understand individual points of view, describe the process, and explore detailed information about the research subject. This research was conducted in July 2022. The subjects in this study were 13 physics teachers and 25 students spread across four provinces in Indonesia, including the provinces of Lampung, DIY, Central Java and West Java. Participants in this study were selected based on a purposive sampling technique, provided they had studied physics on the topic of direct current electricity and agreed to be research subjects.

The data collection procedure uses a non-test technique in the form of an open questionnaire with reasons for each answer. After all the information from the questionnaire was complete, triangulation of data sources was carried out to draw conclusions. The data analysis technique used is the Miles & Huberman analysis technique (2018), which involves three steps: data reduction, data presentation, and drawing conclusions/verification. Reduction means grouping the important thematically and removing the unnecessary. Data display is to understand what happened and plan the next steps—making/reviewing conclusions by answering or not answering problems because qualitative research is temporary and develops after study in the field.

Results and Discussion

Identifying problems found in the field using non-test techniques in the form of open questionnaires was carried out on 13 physics teachers with different backgrounds and teaching experiences. The following table is a generalization of the answers of the 13 predetermined teachers.

Table 1. Problem Identification Results

No.	Indicator	Teacher Response
1	Learning conducted during the covid-19 pandemic	Offline, online and blended.
2	The learning method used	Lectures, discussions, demonstrations, experiments, practicum.
3	The difficulty factor in learning direct current electricity	Limitations of tools for practicum, limitations of learning media, limitations of media and teaching materials that can display various representations simultaneously and limitations of internet signals
4	Direct current electricity topics that are difficult for students to understand	Series-parallel circuits, Kirchoff's laws, determine the branching of currents, imagining the actual flow of current, energy and electric power.
5	Application of multiple representations in learning	Not quite yet.
6	Multiple representations content in teaching materials	It exists but doesn't cover everything.

7	Content of multiple representations on LKPD	It already exists, but there are those who haven't used it. Because the LKPD that is made is just a trial guide as usual.

The results of problem identification show that physics learning is carried out in schools quite varied with the use of learning models and methods that tend to be student-centered, not only lectures but also the teacher encourages students to carry out discussions, experiments, demonstrations, and practicums. However, teachers experience several obstacles in teaching the topic of direct current electricity, namely limited tools for apprenticeship, biased learning media, narrow internet signals, and fixed media and teaching materials that can display various representations simultaneously. Using the suitable representation can improve student performance, especially in understanding concepts and solving problems (Lucas & Lewis, 2019; Opfermann et al., 2017). However, this still needs to be fully implemented in learning, teaching materials, and LKPD. Similar findings were also obtained by Putri et al., (2022) that most teachers have yet to use appropriate learning strategies, methods, and visualizing concepts in multiple representations.

Even though physics learning in schools tends to be student-centered, CPS still needs to be fully implemented in education. Apart from that, there is still learning loss that occurs to students during learning during the pandemic. The following is a more detailed description of the findings regarding CPS and learning loss in the field.

CPS Analysis

From the findings from the non-test questionnaire identification results that were distributed, it was found that some teachers had indirectly carried out activities that led to CPS, but the overall learning process that took place had not been explicitly aimed at training CPS. It is known from the fact that all CPS indicators have not been included in learning activities, teaching materials, and worksheets used by teachers. Time limitations during online and offline learning during the pandemic and the large amount of material that had to be completed resulted in understanding focusing on solving math problems and choosing only core materials to be delivered without paying attention to the CPS skills acquired. The LKPD used by the teacher is still limited to summarizing material, practicing questions, and completing practicum activities in general and has not led to CPS training. The following table is a generalization of the findings of CPS implementation in schools.

Table 2. Results of Identification of CPS in schools

No.	Indicator	Teacher Response
1	Learning trains students to collect information in a systematic way	Already by conducting experiments, collecting data, preparing experimental reports, group discussions, process skills; studying modules; videos and home studies and provide practice questions. Some have not, due to conditions that are not yet possible and still do not support students.

No.	Indicator	Teacher Response
2	Learning trains students to integrate information that is most relevant	Already by analyzing data collection, using digital measuring tools, learning videos, given problems in the form of cases, drawing conclusions, conveying measurement results, and presenting results. Some haven't, because the information comes only from the teacher, only focusing on solving math problems, and the time constraints with the amount of material to work on, so that only the core material is learned.
3	Learning trains students to build mental models from various problem-solving options	Already by developing a small project based on the stimulus, working together in groups to experiment. Not yet, because it only focuses on solving calculation problems. Time constraints with the amount of material that must be worked on. So that only the core materials are learned. Students are still carried away by the atmosphere of online activities during the pandemic.
4	Learning trains students to make predictions, plans and decisions	Already, by involving students in planning the development of prototypes from YouTube then deciding to design and solve problems, make conclusions, discuss for processing and analysis of experimental data and provide practice questions. Some haven't, because they only focus on solving calculation problems and not project base.
5	Learning trains students to implement plans by linking and adjusting action steps as needed to overcome problems	Already, by directing students to explain solving problems based on activities that have been carried out, conducting experiments, collecting data and reading measurement results. Not yet, because I only focus on solving calculation questions. Practical instructions are already available in the LKPD and you just need to follow them

The first question was about student involvement in collecting information systematically, and most of the teachers answered that this activity had been rehearsed during the lesson. However, some of the answers given did not provide detailed information regarding the activities carried out and did not represent the intent of the questions asked. This relates to how students can collect essential information systematically, especially when faced with a complex problem. For example, in learning direct current electric circuits in the series-parallel circuit sub-matter, students are faced with the problem of how to connect a lamp to a circuit that has an electric current source that produces a certain potential difference if the lamp has a certain power and potential difference, where should the lamp be placed? And how the circuit should be arranged. This certainly requires deep thinking, where students need to collect basic information first to be able to solve the problems presented, such as knowing what circuit to use, how many resistances need to be installed, the concept of voltage, current strength and resistance and their relationship with power, and so on. Students are expected to understand physics concepts and apply the concepts they know when solving problems (Wardani et al., 2021). This is one of the critical characteristics of complex problems, i.e. they contain some degree of non-transparency where not all information is available from the outset (Gnaldi et al., 2020). One is often confronted with new problems characterized by uncertainty, connectivity, lack of transparency/ambiguity, and complexity (Grežo & Sarmány-Schuller, 2022). Complexity means that a complex problem involves a set of interrelated variables in which several causal relationships are established. Interconnectivity, on the other hand, implies some degree of dynamics because systems may change over time. This change can be driven by input from the problem solver or by the development of momentum during the problem-solving process (Gnaldi et al., 2020). Therefore, gathering information from various sources that can help find pieces of the problem is the primary key that needs to be done.

The teacher's response to the second question regarding student activities in integrating the most relevant information indicates that these activities still need to be fully carried out during learning. Some teachers who answered that they did not practice these activities gave the excuse that the information was only provided by the teacher and time constraints were the cause of the intended activities not being carried out so that the learning process only focused on conveying the core material and solving math problems. Although some teachers answered that the activity had been trained, the method of training described needed to represent the intent of the questions given. This means that the teacher may need help understanding the purpose of the activity. The purpose of integrating the most relevant information here is that after collecting various sources to find pieces of the problem that are not yet clear, students sort and integrate one piece of information with other information, which can be a guide for finding problems and creating solutions. For example, after some information is obtained, such as the concept of voltage, current and resistance and their power relationship, the purpose of a lamp that has a specific power and potential difference, students integrate the most relevant information to form an appropriate problem-solving framework.

The lack of information transparency requires the problem solver to interact actively with complex systems to uncover hidden relationships. Otherwise, the real problem will remain undetected. In other words, without processes to proactively address problems, relevant information remains hidden and planned and targeted solutions to problems are impossible (Gnaldi et al., 2020). As already mentioned, in complex problems, the situation can change dynamically, and only some of the information needed to find a solution is presented beforehand. In this case, it isn't easy to make a complete plan before doing it (Eichmann et al., 2019a). Therefore, sorting and integrating some information is crucial to make it easier for students to determine solutions. Integrating, synthesizing problems, and analyzing data directly can develop CPS capabilities (Putra, 2021). The ability to solve complex problems is usually measured through dynamic systems that contain several interrelated variables that need to be changed (Dörner & Funke, 2017).

The third question related to student involvement in building mental models of various problem-solving options. Some of the teachers answered that they had trained them in group discussion activities and doing small projects based on a stimulus. However, the activities mentioned were still general. They should have explained the discussion and creation of what kind of project and how it was carried out so that the activities in question could emerge. The cognitive framework of solving problems suggests that a problem can be tackled through various problem-solving techniques. For example, when faced with a problem where a lamp can be connected so that it still has a distinct predetermined potential difference, students can use a mathematical equation or represent it in other forms, such as pictures or circuits. In complex systems, learning can only occur at a very general and abstract level because it is difficult for human observers to make specific predictions. The way to deal with complex systems is very different from the way to deal with ordinary systems. Pure learning effects, multi-key probabilistic learning or tasks solved by a single strategy should not be studied under the CPS label (Dörner & Funke, 2017). A systematic way of exploring complex problems may be directly related to constructing a correct mental representation of the problem (Greiff & Fischer, 2013). Building a mental model when involved with complex problems is highly recommended because it helps students break down information that is not transparent.

As for the response to the fourth question related to training students to make forecasts, plans and decisions, the teacher who answered had yet to do so, considered that the learning activities carried out were not project-based and problem-based, so this could not be implemented. Whereas the teacher who answered that he had done so gave a clear description of the activities, what problems were given, whether they were related to complex systems or ordinary systems were not explained in detail. When dealing with complex systems, making forecasts, plans and decisions cannot be done just like that but must involve the three previous components: systematically collecting information, integrating the most relevant information, and creating a mental model of a problem. If the previous components are not met, making forecasts, plans and decisions when dealing with complex systems is not easy. This is in line with the statement expressed by Dörner & Funke (2017) that solving complex problems is not a one-dimensional and low-level construction. Complex problem-solving is a series of self-coordinated psychological processes and activities required in a dynamic environment to achieve vague goals that everyday behaviour cannot achieve. This requires a creative combination of knowledge and various strategies. The solutions obtained often come from unexpected things. The problem-solving process incorporates cognitive, emotional, and motivational aspects, especially in high-stakes situations. Complex problems usually involve knowledge requirements and collaboration between different people.

On the fifth question, some teachers answered that students had been trained to implement plans by connecting and adjusting action steps as needed to solve problems. However, the activities carried out have yet to represent the desired answer fully. Explaining problem-solving, conducting experiments and, reading measurement results, discussing data collection and analysis are some of the activities that the teacher describes to train them. More than that, establishing an action plan and adapting as needed relates to setting and balancing goals to find solutions to complex problems based on the mapping of problems that have been done. CPS is a dynamic process that scales over time, with distinct phases beyond knowledge acquisition and application. A process that leads to a solution, including detours and mistakes, can give a more precise impression of a person's problem-solving skills and abilities than the result. That is one of the reasons why this test is not a complex intelligence test. Research on CPS is not only about the decision-making process results but also about the problem-solving process itself (Dörner & Funke, 2017).

Based on the description above, the results show that CPS still needs to be fully implemented in physics learning. The answers and descriptions explained by the teacher indicated that some teachers needed to fully understand the CPS indicators so that there was confusion in practising them during the learning process. CPS competence is the main competency that students must have, especially to face the challenges of the 21st century. Glazewski & Ertmer (2020) advocates an approach to teaching complex problem-solving that requires a deeper understanding of and commitment to culturally relevant education. These shifts in practice are guided by an understanding of students' cultural context, addressing critical reflection coupled with meaningful action, and generating problem-solving designs that promote identification with the discipline. The characteristics of complex problem-solving environments help teachers go beyond standard practices and take meaningful actions that help bridge educational gaps. CPS ability is associated with environmental factors of students by providing various feedback and brainstorming (Putra, 2021). Students with higher CPS abilities can use prior knowledge more proficiently when learning new content; thus, their learning is faster and more profound. CPS has been considered an indicator of academic achievement and a leading indicator of achievement in other skills. Given the increasing importance and needs of CPS today and in the future, students' abilities are not accompanied by an increase in complex problem-solving abilities, so continuous research is needed to improve students' CPS abilities (Asfar et al., 2021). Increasing CPS's ability can be trained during the learning process, so it is necessary to develop a learning program that can train CPS.

Learning Loss Analysis

Nine out of 13 teachers reported that learning during the Covid-19 pandemic was not effective and optimal. Several factors cause the ineffectiveness of learning during a pandemic. The following table is a summary of teacher responses to learning effectiveness and learning loss that occurs in schools.

Table 3. Teacher responses regarding the effectiveness of learning during the pandemic and indications of learning loss

No.	Indicator	Teacher Response
1	The effectiveness of learning implemented during the Covid-19 pandemic	In general it is still not effective because students are still carried away by online learning so they are a little lazy when in class, many hours are cut so that the material and learning model provided are not optimal, environmental conditions and student psychology are not conducive, and signal limitations and the environment is not supportive.
2	Indications of learning loss experienced by students during learning that was implemented during the Covid-19 pandemic	Student discipline is reduced from starting class hours, students rarely submit assignments, then the internet is limited, due to time constraints in the implementation of learning, students tend to be busy playing games a lot.

Some teachers stated that there were no problems in learning because they had done face-to-face meetings. While for others, even though learning has been carried out face-to-face, the reduction in the allocation of class time, environmental conditions and student psychology that is not conducive and students who are still carried away by the atmosphere of online learning are obstacles that result in less effective learning. As for schools that carry out learning activities online, limited internet signals and an unsupportive learning environment are different obstacles to learning activities. In addition, teacher readiness to carry out online learning also impacts learning effectiveness. Research by Fajriana & Safriana (2021) reveals that physics teacher readiness in implementing online education is ready but requires a slight increase in ability on the medium scale, including the teacher's ability to implement online learning, which can improve the teaching and learning process, teacher concern in implementing online learning in schools and the ability to integrate online learning with classroom learning.

The ineffectiveness of the learning carried out impacts the number of students who experience setbacks in learning and a decrease in academic progress (learning loss). Most teachers admit that their students experience setbacks in learning and a decline in academic progress. Some student behaviours that rarely submitting assignments reduced discipline when entering class, tending to be busy playing games, and decreased academic scores indicate symptoms of learning loss experienced. In addition to external factors, the teacher reported several things that became a factor of difficulty in carrying out learning. These factors include limitations to internet signals, limitations of tools for conducting practicums, limitations of learning media, and limitations of media and teaching materials that simultaneously display concepts with various representations.

This is in line with the student's perspective. As many as 18 out of 25 students admitted that the learning during the Covid-19 pandemic was not effective and maximal. This ineffectiveness is influenced by several factors, including difficulty understanding the material, lack of direct explanation from the teacher, difficulty focusing during learning, limited time for learning to limited internet networks. As many as 17 out of 25 students admitted to experiencing a setback in learning and a decrease in academic progress. While the rest said, they could cope by signing up for tutoring outside of school, studying more actively at home, repeating the material they had learned and looking for additional material through several websites on the internet. Students who responded that online learning during the pandemic remained effective and optimal were probably due to the increased independence of the student's learning. Students' attitudes toward online learning are very important. Having a positive attitude towards online learning can affect their learning process (Maison et al., 2021). Online learning encourages students to study independently and explore other things. This activity can help improve students' thinking skills. This can be seen as one of the positive aspects of implementing online learning. Although of course, not all students can adapt and learn independently (Rajib & Sari, 2022)

The emergence of a paradigm shift in teacher-directed learning systems, such as the virtualization of face-to-face learning and gadgets, has developed an opinion about the emergence of learning loss in students. Because the material available on various internet platforms tends to provide brief content, some children may need help understanding the material presented (Rizaldi et al., 2022). Students have relatively low self-confidence in dealing with learning problems. When students receive questions or assignments from subject teachers, they tend to immediately seek answers from various internet sources without verifying the answers' correctness. Very few students answered their questions and then looked at various sources as references or benchmarks for the answers given. Although the two conditions look similar, they are very different in terms of the processes students go through. With technology like this, everything is considered easy to get, making students lazy to do anything. This is what every teacher faces when giving assignments and questions to students to do at home. Teachers cannot directly monitor the process of solving student problems during online learning (home learning). Teachers can only see the final results of tasks completed by students (Rizaldi et al., 2022).

Forces to Increase CPS and Minimize Learning Loss

From the findings of the CPS analysis, a brief description is obtained that solving complex problems requires various activities that involve several cognitive processes, but this is only partially present when carrying out learning. The diverse and unique characteristics of students make it a challenge to be able to accommodate learning optimally. Therefore it is necessary to have a strategy to facilitate students' different learning needs, one of which emphasizes learning by using Multiple Representations in conveying the concept. Learning resources related to visualization can be important things that can facilitate students understanding abstract concepts (Apriani et al., 2021) Several learning studies using MRs show that student performance improves when interacting with appropriate representations (Fatmaryanti & Nugraha, 2019; Lucas & Lewis, 2019; Munfaridah et al., 2021). This may indicate that learning loss can be reduced by using MRs. In addition, external MRs can help students understand concepts and help them solve problems (Citra et al., 2020; Fatmaryanti & Nugraha, 2019; Opfermann et al., 2017). The use of MRs in learning can be one of the efforts that can be made to improve students' CPS skills.

Meanwhile, online learning only sometimes has a negative impact on students. Some of the benefits obtained are also countless (Dumford & Miller, 2018; Yuhanna et al., 2020). So that online learning cannot be immediately eliminated. To overcome the disadvantages and still benefit from online learning, blended learning is seen as one of the innovations that need to be adopted (Dangwal, 2017). The blended concept, which combines face-to-face meetings (offline) and meetings through discussion forums (online), is one of the recommended solutions in learning during the past Covid-19 pandemic, transition period, and distance learning (Purwanti et al., 2022). The blended environment provides firm support and creates opportunities for students to actively shape their own (Montgomery et al., 2019), learning so that learning loss can be minimized. Blended learning activities can also encourage their involvement in collaborative discussions and motivate them to perform tasks (Suana et al., 2019) that can support them in solving complex problems. Therefore, using MRs in blended learning programs is seen as an effort to improve CPS skills and reduce learning los-los.

Conclusion

Based on the research results, it was concluded that CPS had yet to be fully implemented in physics learning in secondary schools. Learning during the Covid-19 pandemic was ineffective and maximal, which resulted in most students experiencing setbacks in learning and a decrease in academic progress (learning loss). Therefore, it is necessary to develop learning programs that can support student learning processes independently and under the supervision of teachers at school. A blended learning program based on multiple representations is needed as a learning unit that can stimulate CPS and reduce learning loss.

References

Abdurrahman, A., Setyaningsih, C.A., & Jalmo, T. 2019. Implementating multiple representation-based worksheet to develop critical thinking skills. *Journal of Turkish Science Education*, 16(1):138–155. https://www.tused.org/index.php/tused/article/view/235

Ainsworth, S. 2006. DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction*, 16(3):183–198. https://doi.org/10.1016/j.learninstruc.2006.03.001.

Apriani, R., Harun, A.I., Erlina, E., Sahputra, R., & Ulfah, M. 2021. Pengembangan modul berbasis multipel representasi dengan bantuan teknologi augmented reality untuk membantu siswa memahami konsep ikatan kimia. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 5(4):305–330. http://dx.doi.org/10.24815/jipi.v5i4.23260.

Arikunto, S. 2019. *Prosedur penelitian suatu pendekatan praktik*. Jakarta: Rineka Cipta.

Asfar, A. & Sulastri, S. 2021. Improving student's complex problem solving through LAPS-Talk-Ball learning integrated with interactive games. *Journal of Physics: Conference Series*, 1722(1):012105 1-7. DOI 10.1088/1742-6596/1722/1/012105

Aucejo, E.M., French, J., Araya, M.P.U., & Zafar, B. 2020. The impact of covid-19 on student experiences and expectations: Evidence from a survey. *Journal of Public Economics*, 191(1):104271 1-15. https://doi.org/10.1016/j.jpubeco.2020.104271

Bhagat, K.K., & Spector, J.M. 2017. Formative assessment in complex problem-solving domains: The emerging role of assessment technologies. *Educational Technology and Society*, 20(4):312–317. https://www.jstor.org/stable/26229226

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. 2012. Defining twenty-first century skills. In: Griffin, P., McGaw, B., Care, E. (eds) Assessment and Teaching of 21st Century Skills. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-2324-5_2

Calderón, A., Scanlon, D., MacPhail, A., & Moody, B. 2021. An integrated blended learning approach for physical education teacher education programmes: teacher educators' and pre-service teachers' experiences. *Physical Education and Sport Pedagogy*, 26(6): 562–577. https://doi.org/10.1080/17408989.2020.1823961

Chen, L.K. Dorn, E., Sarakatsannis, J., & Wiesinger, A. 2021. Teacher survey : Learning loss is global and significant (*Mckinsey & Company*). Retrieved from https://www.ninikpsmalang.net/download/file/Teacher_Survey_Learning_Loss_.pdf

Citra, C., Distrik, I.W., & Herlina, K. 2020. The Practicality and Effectiveness of Multiple Representations Based Teaching Material to Improve Student's Self-Efficacy and Ability of Physics Problem Solving. *Journal of Physics: Conference Series*, 1467(1):012029 1-8. https://doi.org/10.1088/1742-6596/1467/1/012029

Citra, K.A., Nehru, N., Pujaningsih, F.B., & Riantoni, C. 2021. Keterampilan pemecahan masalah siswa pada materi listrik arus searah di masa pembelajaran jarak jauh. *Jurnal Pendidikan Fisika dan Teknologi*, 7(2):75–79. http://dx.doi.org/10.29303/jpft.v7i2.2663

Csapó, B. and Funke, J. 2017. The Nature of Problem Solving: Using Research to Inspire 21st Century Learning, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264273955-en

Dangwal, K.L. 2017. Blended learning: An innovative approach. *Universal Journal of Educational Research*, 5(1):129–136. https://eric.ed.gov/?id=EJ1124666

Dorn, E., Hancock, B., Sarakatsannis, J., & Viruleg, E. 2020. Covid-19 and learning loss—disparities grow and students need help. *McKinsey & Company,* 12(8):224–228. https://wasa-oly.org/

Dörner, D. 1986. Diagnostik der operativen Intelligenz [Diagnosis of operative intelligence]. *Diagnostica*, 32(4):290–308. https://psycnet.apa.org/record/1989-71230-001

Dörner, D. & Funke, J. 2017. Complex problem solving: What it is and what it is not. *Frontiers in Psychology*, 8(7):1–11. https://doi.org/10.3389/fpsyg.2017.01153

Dumford, A.D., & Miller, A.L. 2018. Online learning in higher education: exploring advantages and disadvantages for engagement. *Journal of Computing in Higher Education*, 30(3):452–465. https://doi.org/10.1007/s12528-018-9179-z

Eichmann, B., Goldhammer, F., Greiff, S., Pucite, L., & Naumann, J. 2019a. The role of planning in complex problem solving. *Computers and Education*, 128(7):1–12. https://doi.org/10.1016/j.compedu.2018.08.004

Eichmann, B., Greiff, S., Naumann, J., Brandhuber, L., & Goldhammer, F. 2020. Exploring behavioural patterns during complex problem-solving. *Journal of Computer Assisted Learning*, 36(6):933–956. https://doi.org/10.1111/jcal.12451

Fajriana, F., & Safriana, S. 2021. Analisis kesiapan guru fisika dan matematika dalam pembelajaran daring. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(2):293–304. https://jurnal.usk.ac.id/JPSI/article/view/19162/13801

Fatmaryanti, S.D. & Nugraha, D.A. 2019. Using multiple representations model to enhance student's understanding in magnetic field direction concepts. *Journal of Physics: Conference Series*, 1153(1):012147 1-5. DOI 10.1088/1742-6596/1153/1/012147

Fischer, A., Greiff, S., & Funke, J. 2012. The process of solving complex problems. *The Journal of Problem Solving*, 4(1): 19-42 https://doi.org/10.7771/1932-6246.1118

Funke, J., Fischer, A., & Holt, D.V. 2018. Competencies for Complexity: Problem Solving in the Twenty-First Century. In: Care, E., Griffin, P., Wilson, M. (eds) Assessment and Teaching of 21st Century Skills. Educational Assessment in an Information Age. Springer, Cham. https://doi.org/10.1007/978-3-319-65368-6_3

Glazewski, K.D. & Ertmer, P.A. 2020. Fostering complex problem solving for diverse learners: engaging an ethos of intentionality toward equitable access. *Educational Technology Research and Development*, 68(2):679–702. https://doi.org/10.1007/s11423-020-09762-9

Gnaldi, M., Bacci, S., Kunze, T., & Greiff, S. 2020. Students' complex problem solving profiles. *Psychometrika*, 85(2):469–501. https://doi.org/10.1007/s11336-020-09709-2

Graesser, A.C., Foltz, P.W., Rosen, Y., Shaffer, D.W., Forsyth, C., & Germany, M.L. 2018. Challenges of Assessing Collaborative Problem Solving. In: Care, E., Griffin, P., Wilson, M. (eds) Assessment and Teaching of 21st Century Skills. Educational Assessment in an Information Age. Springer, Cham. https://doi.org/10.1007/978-3-319-65368-6_5.

Graesser, A., Kuo, B.C., & Liao, C.H. 2017. Complex problem solving in assessments of collaborative problem solving. *Journal of Intelligence*, 5(2):1–14. https://doi.org/10.3390/jintelligence5020010

Greiff, S. & Fischer, A. 2013. Measuring complex problem solving: an educational application of psychological theories. *Journal for Educational Research Online*, 5(1):38–58. https://doi.org/10.25656/01:8019

Grežo, M. & Sarmány-Schuller, I. 2022. It is not enough to be smart: on explaining the relation between intelligence and complex problem solving. *Technology, Knowledge and Learning*, 27(1):69–89. https://doi.org/10.1007/s10758-021-09498-2

Herde, C.N., Wüstenberg, S., & Greiff, S. 2016. Assessment of complex problem solving: what we know and what we don't know. *Applied Measurement in Education*, 29(4):265–277. https://doi.org/10.1080/08957347.2016.1209208

Hidayat, S., Apriliya, S., & Fauziyaturrosyidah, A. 2021. Metode gamification sebagai solusi fenomena learning loss dalam pembelajaran daring selama pandemi covid-19: a literatur review. *Journal of Elementary Education*, 4(5):741-753. https://www.journal.ikipsiliwangi.ac.id/index.php/collase/article/view/8815

Kohl, P.B. & Finkelstein, N. 2017. Understanding and Promoting Effective Use of Representations in Physics Learning. In: Treagust, D., Duit, R., Fischer, H. (eds) Multiple Representations in Physics Education. *Models and Modeling in Science Education, vol 10. Springer, Cham. https://doi.org/10.1007/978-3-319-58914-5_11*

Kurniawan, H. & Budiyono. 2021. Heroe's model: Case study to reduce students' learning loss and anxiety. *Cypriot Journal of Educational Sciences*, 16(3):1122–1140. https://doi.org/10.18844/CJES.V16I3.5830

Li, A., Harries, M., & Ross, L.F. 2020. Reopening K-12 schools in the era of coronavirus disease 2019: review of State-Level guidance addressing equity concerns. *The Journal of Pediatrics*, 227(12):38–44. https://doi.org/10.1016/j.jpeds.2020.08.069

Lucas, L.L. & Lewis, E.B. 2019. High school students' use of representations in physics problem solving. *School Science and Mathematics*, 119(6):327–339. https://doi.org/10.1111/ssm.12357

Maison, M., Kurniawan, D.A., & Anggraini, L. 2021. Perception, attitude, and student awareness in working on online tasks during the covid-19 pandemic. *Jurnal Pendidikan Sains Indonesia*, 9(1):108–118. https://jurnal.usk.ac.id/JPSI/article/view/18039

Montgomery, A.P., Mousavi, A., Carbonaro, M., Hayward, D.V., & Dunn, W. 2019. Using learning analytics to explore self-regulated learning in flipped blended learning music teacher education. *British Journal of Educational Technology*, 50(1):114–127. https://doi.org/10.1111/bjet.12590

Munfaridah, N., Avraamidou, L., & Goedhart, M. 2021. The use of multiple representations in undergraduate physics education: what do we know and where do we go from here? *Eurasia Journal of Mathematics, Science and Technology Education*, 17(1):1-19. https://doi.org/10.29333/ejmste/9577

Nofitasari, I. & Sihombing, Y. 2017. Deskripsi kesulitan belajar peserta didik dan faktor penyebabnya dalam memahami materi listrik dinamis kelas X SMA Negeri 2 Bengkayang. *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*, 7(1):44–53. https://doi.org/10.26740/jpfa.v7n1.p44-53

Opfermann, M., Schmeck, A., Fischer, H.E. 2017. Multiple Representations in Physics and Science Education – Why Should We Use Them?. In: Treagust, D., Duit, R., Fischer, H. (eds) Multiple Representations in Physics Education. *Models and Modeling in Science Education*, vol 10. Springer, Cham. https://doi.org/10.1007/978-3-319-58914-5_1

Pradnyana, I.K.A., Pradnyana, I.M.A., & Suyasa, P.W.A. 2020. Pengembangan multimedia pembelajaran interaktif PPKN untuk siswa tunagrahita dengan konsep gamifikasi. *Jurnal Pendidikan Teknologi dan Kejuruan*, 17(2):166–176. https://doi.org/10.23887/jptk-undiksha.v17i2.25189

Purniasih, N.K.D., Darmawiguna, I.G.M., & Agustini, K. 2020. Pengembangan media pmbelajaran sumber energi berorientasi gamifikasi untuk siswa kelas 4 North Bali Bilingual School. *Jurnal Pendidikan Teknologi dan Kejuruan*, 17(1):1–10. https://ejournal.undiksha.ac.id/index.php/JPTK/article/view/21428

Purwanti, A., Hujjatusnaini, N., Septiana, N., Amin, A.M., & Jasiah, J. 2022. Analisis keterampilan berpikir kritis mahasiswa melalui model blended-project based learning terintegrasi keterampilan abad 21 berdasarkan students skill level. *JIPI (Jurnal IPA & Pembelajaran IPA*), 6(3):236–246. https://jurnal.usk.ac.id/JIPI/article/view/25705/16295

Putra, I.M.Y.T. 2021. Implementasi pembelajaran flipped classroom berbasis diferensia untuk meningkatkan keterampilan berpikir kritis peserta didik. *Indonesian Journal of Educational Development*, 2(3):461–471. https://doi.org/10.5281/zenodo.5681318

Putrama, I.M. & Suyasa, P.W.A. 2020. Pengembangan media pembelajaran interaktif "pengenalan hewan dan tumbuhan" pada mata pelajaran ilmu pengetahuan alam (ipa) dengan metode gamefikasi untuk siswa kelas II di Sekolah Dasar (Studi kasus: SDN 2 Batur). *KARMAPATI (Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika)*, 9(1):8–20. https://doi.org/10.23887/karmapati.v9i1.23270

Putri, A., Lengkana, D., & Jalmo, T. 2022. Teacher's perceptions of electronic multi representation stem based worksheet to improve student's metacognitive ability. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(3):606–622. https://jurnal.usk.ac.id/JPSI/article/view/25052

Qodr, T.S. 2020. Media pembelajaran game geograpiea untuk anak sekolah dasar di era digital. *Journal of Curriculum Indonesia*, 3(2):45–53. http://hipkinjateng.org/jurnal/index.php/jci/article/view/29

Rajib, M. & Sari, A.P. 2022. Potensi learning loss di SMA Negeri 4 Polewali selama pembelajaran daring pada masa pandemi covid-19. *BIOMA: Jurnal Biologi Dan Pembelajarannya*, 4(1):40–48. https://doi.org/10.31605/bioma.v4i1.1592

Rizaldi, D.R., Fatimah, Z., Susilawati, S., & Makhrus, M. 2022. Student responses related to face-to-face learning policies to overcome learning loss condition. *Journal of Science and Science Education*, 3(1):9–16. https://doi.org/10.29303/jossed.v3i1.1309

Sabates, R., Carter, E., & Stern, J.M.B. 2021. Using educational transitions to estimate learning loss due to covid-19 school closures: The case of complementary basic education in Ghana.

International Journal of Educational Development, 82 102377:1-9. https://doi.org/10.1016/j.ijedudev.2021.102377

Schefer-Wenzl, S., & Miladinovic, I. 2019. Developing complex problem-solving skills: an engineering perspective. *International Journal of Advanced Corporate Learning (IJAC)*, 12(3):82-88. https://doi.org/10.3991/ijac.v12i3.11067

Suana, W., Distrik, I.W., Herlina, K., Maharta, N., Putri, A. 2019. Supporting blended learning using mobile instant messaging application: its effectiveness and limitations. *International Journal of Instruction*, 12(1):1011–1024. https://doi.org/10.29333/iji.2019.12165a

Tangkui, R. & Keong, T.C. 2020. Kesan pembelajaran berasaskan permainan digital minecraft terhadap pencapaian murid tahun lima dalam pecahan. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 5(9):98–113. https://doi.org/10.47405/mjssh.v5i9.476

Tomasik, M.J., Helbling, L.A., & Moser, U. 2021. Educational gains of in-person vs. distance learning in primary and secondary schools: A natural experiment during the covid-19 pandemic school closures in Switzerland. *International Journal of Psychology*, 56(4):566–576. https://doi.org/10.1002/ijop.12728

Vollmeyer, R., Burns, B.D., & Holyoak, K.J. 1996. The impact of goal specificity on strategy use and the acquisition of problem structure. *Cognitive Science*, 20(1):75–100. https://doi.org/10.1207/s15516709cog2001_3

Wahyuni, S., & Handhika, J. 2019. Profil kesulitan belajar pokok bahasan listrik dinamis siswa SMK. *SNPF (Seminar Nasional Pendidikan Fisika)*. 2527-6670:286-289. http://prosiding.unipma.ac.id/index.php/SNPF/article/view/741

Wardani, T.M., Evendi, E., Mudatsir, M., & Susanna, S. 2021. Implementasi model physics independent learning untuk meningkatkan kemampuan pemecahan masalah fisika peserta didik. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 5(4):259–268. https://jurnal.usk.ac.id/JIPI/article/view/23150

Wu, J.H., Tennyson, R.D., & Hsia, T.L. 2010. A study of student satisfaction in a blended e-learning system environment. *Computers & Education*, 55(1):155–164. https://doi.org/10.1016/j.compedu.2009.12.012

Wyse, A.E., Stickney, E.M., Butz, D., Beckler, A., & Close, C.N. 2020. The potential impact of covid-19 on student learning and how schools can respond. *Educational Measurement: Issues and Practice*, 39(3):60–64. https://doi.org/10.1111/emip.12357

Yarrow, N., Masood, E., & Afkar, R. 2020. *Estimates of covid-19 Impacts on Learning and Earning in Indonesia : How to Turn the Tide*. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/34378

Yuhanna, I., Alexander, A., & Kachik, A. 2020. Advantages and disadvantages of online learning. *Journal Educational Verkenning*, 1(2):13–19. https://doi.org/10.48173/jev.v1i2.54

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Development of Microsoft Power Point Interactive Media Based on Visual Basic for Application as Middle School Science Learning Media

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Abstract. Learning systems in the 21st century require a variety of interactive learning media. The purpose of this study is to develop an interactive microsoft power point media based on visual basic for application on vibration, wave, and sound material. This study method is a type of research and development (R&D) using the ADDIE development model which consists of analysis, design, development, implementation, and evaluation stages. The population in this study at the field trial stage were all students of class VIII SMPN 1 Logas Tanah Darat. The sampling technique for this study used purposive sampling, namely determining the sample according to research needs. The research sample at the field trial stage consisted of 28 students. The data collection technique in this study was in the form of distributing questionnaires and administering tests. The validation data analysis technique uses the Aiken V validity index formula, while the analysis of practicality and effectiveness test data uses the average formula. The results of this study indicate that the results of the overall validity test index get an Aiken V validity of 0.86 with a high validity category. In addition, the results of the practical test analysis reached 83.25% in the very practical category. The results of the analysis of effectiveness get the proportion of 82.14% so that the developed media is effective. Thus it can be concluded that the microsoft power point interactive media based on visual basic for application developed are valid, practical and effective.
Keywords: interactive media, microsoft power point, visual basic for application.

Introduction

The growth of increasingly sophisticated technology, humans must be able to adapt to today's sophistication. This technological sophistication has not only penetrated society but also the world of education (Andryansah et al., 2021). Currently, the use of information and communication technology is a requirement that must be met in order to create a reliable and globally competitive generation (Soimah, 2018). The presence of technology helps teachers and students to facilitate learning activities, especially as intermediaries for messages in learning or commonly referred to as learning media (Bungawati & Rahmadani, 2023).

The low quality of education is reflected in the low student learning outcomes. However, in reality, science learning outcomes are still low, both qualitatively and quantitatively. This is evidenced by the results of the 2018 PISA which recorded a decrease in the scientific literacy score in Indonesia from 403 to 396 (OECD, 2019). Learning success is determined and influenced by students and the media learning used by the teacher in the classroom. Lack of use of learning media in activities learning can cause learning to become monotonous, and uninteresting and eventually affect student learning outcomes (Wafiq et al., 2021)

Physics material is material that is difficult for students to understand, especially material that contains calculations such as vibration, wave, and sound material. This is supported by the results of a study by Pratiwi et al, (2022) it was found that students had difficulty working on vibration, wave, and sound material questions. Teachers also have difficulty visualizing vibration, wave, and sound material, causing problems in giving material to books. This was also combined with the results of interviews with several students, namely they were also less motivated to read teaching materials at school such as textbooks that are usually used for learning.

In addition, the material used is usually in the form of mandatory books published by the ministry of education and culture, so that new material variations do not appear during learning. As a result, students lose interest and do not pay attention to learning, and students cannot understand what is being taught. This problem becomes a major obstacle in learning every year and can cause teachers to package material in such a way that students learn independently and have a good understanding of the material (Rahmawati et al., 2020).

There are problems faced by the teacher when conveying vibration, wave and sound material, so a tool is needed that can visualize and concretize the material already contained in the book. The use of media is very important for teachers to support the process learning because it can increase the attractiveness of students in learning so that the level of understanding can increase (Wulandari et al., 2020). Therefore, learning media need to be developed by the curriculum and the needs of students to create a fun, interesting, learning process, Interactive, and assist students in understanding the material so that learning objectives can be achieved with good (Mulyono et al., 2019). According to Wirangga et al. (2018) states that one of the learning media that can be used as a solution to accommodate student characteristics is interactive media. This interactive media uses a combination of text, graphics, animation, sound and video to make students more active and innovative in the learning process.

One medium that is easy to use and quite familiar to learn is microsoft powerpoint. in microsoft powerpoint there is an interactive visual basic for application (VBA) menu. The combination of power point and VBA is able to make videos and questions interactively. VBA is a programming language or macro specifically designed for microsoft office and is slightly different from the usual visual basic (Anomeisa & Ernaningsih, 2020). To determine the feasibility of learning media, it is necessary to pay attention to suitability, accuracy, timeliness, clarity, and screen layout and presentation.

One solution that can be applied to overcome the problems described earlier is the use of learning aids. Learning media helps students understand abstract concepts to be more concrete and understand learning material (Muzanni & Zinnurain, 2018; Namiroh, 2019; Octafiana et al., 2018). Learning media can attract students' interest and motivation to learn (Husna et al., 2017). Interactive multimedia is a technology-based learning media that can be used as a transformative medium to create an interesting and active learning process (Chan et al., 2019; Mukmin & Primasatya, 2020; Sofwan & Wibowo, 2019). Interactive multimedia is a composition of several media, including text, images, animations, and videos that are packaged into digital files that are used to transmit news broadcasts and collect data, and ultimately interact with each other. Exchange of ideas or broader elements of communication involving users and the media (Maruti, 2016; Rambe & Saragih, 2016; Sintya et al., 2020).

Several studies have shown that the use of interactive multimedia helps students understand the material (Firmansyah et al., 2020). Interactive multimedia is more feasible when used with math content (Aprianty et al., 2021; Dewi & Haryanto, 2019). The benefit of using interactive multimedia is to increase student activity in the learning process. This is because students are directly involved in the process, making learning more interesting and fun, giving students new learning experiences, helping students understand the material, and generating interest in learning motivation. This research aims to develop microsoft powerpoint interactive media based on visual basic for application.

Methods

This type of research is research and development (R&D) (Ibrahim et al., 2020). The steps for developing interactive media for microsoft powerpoint based on visual basic for applications refer to the ADDIE model, namely the stages of analysis, design, development, implementation and evaluation (Ernawati et al., 2022; Ratnasari et al., 2020).

Problem analysis, needs analysis, and curriculum analysis complete the analysis phase. Next is the design stage, namely designing the initial design of microsoft powerpoint based on visual basic for applications, and also designing the codes that will be used in interactive media. The development stage is forming the basic plan into a prototype, then validating and revising it based on the validator's comments and ideas. Students are given media trials during the implementation stage to find out whether or not the learning media is appropriate. Based on student responses, an evaluation and revision of the learning material was carried out at the evaluation stage.

In this study used a questionnaire and tests to collect data. In this study, validity analysis, practicality analysis, and effectiveness analysis were used to analyze the data. Based on the findings of data analysis from the lecturer and science teacher learning media validation sheet, the learning media was declared valid. Analyzing the data with research instruments in the form of media validation sheets consisting of aspects of design, pedagogy, content, and techniques. The validation sheet instrument grid is presented as in Table 1.

Table 1. Validation Sheet Instrument Grid

No	Aspects	Questions
1	Design	1-9
2	Pedagogic	10-19
3	Content	20-28
4	Technical	29-36

(source: Nasir, 2017)

Table 2 shows the rating scale used for each validation item, using a Likert scale of 1 to 5.

Table 2. Assessment of Validation Items

No	Alternative answer	Score
1	Strongly agree	5
2	Agree	4
3	Disagree	3
4	Don't agree	2
5	Totally disagree	1

(source: Sugiyono, 2019)

The data from filling out the product validation sheet by the validator is analyzed to determine the level of product validity using the Aiken's V validity index (Aiken, 1980; Bashooir & Supahar, 2018; Dewi et al., 2020; Ratnasari et al., 2020) each item is calculated using the formula:

$$V = \frac{\Sigma s}{n(c-1)} \quad (1)$$

Where V is the validity index of Aiken; Σs score set by each rater minus the lowest score, n the number of raters; and c the number of categories the rater can choose from.

After obtaining the Aiken V validity index value, then the validity level is categorized based on Table 3.

Table 3. Product Validity Level

No	Value range	Category
1	$V \leq 0.4$	Low validity
2	$0.4 > V > 0.8$	Moderate validity
3	$V \geq 0.8$	High validity

(source: Ibrahim et al., 2020)

Microsoft powerpoint interactive media based on visual basic for application is declared valid and suitable for use in learning, if the results of the validity analysis meet the high validity category (Dewi et al., 2020; Ibrahim et al., 2020; Susanto & Retnawati, 2016). Then determine the practicality level of the media by using a Likert Scale 1-5 as well, with a grid of student practicality instruments that can be seen in Table 4.

Table 4. Student Practical Instruments Lattice

No	Aspects	Questions
1	Content Quality	1-5
2	Engineering Quality	6-9
3	Quality of learning	10-13
4	Efficiency	14-16

(source: Amatullah, 2021)

The practicality value of the media, the researcher analyzed by adding up the values of all the questionnaires divided by the maximum total value of the media practicality questionnaire then multiplied by 100%. Then the level of practicality is categorized based on Table 5.

Table 5. Product Practicality Level

No	Practicality Level (%)	Category
1	81 – 100	Very Practical
2	61 – 80	Practical
3	41 – 60	Enough Practical
4	21 – 40	*Less Practical*
5	0 – 20	Impractical

(source: Yanto, 2019)

Student learning outcomes test determines the effectiveness of learning media. The researcher analyzed using the number of students who passed the KKM divided by the total number of students and then multiplied by 100% (Nasution et al., 2020). Microsoft powerpoint interactive media based on visual basic for application is declared effective if a minimum percentage of completeness reaches 80% and students can achieve a score that is in accordance with the KKM.

Results and Discussion

This research produced a product in the form of microsoft power point interactive media based on visual basic for the application of vibration, wave and sound material. Presentation of vibration, wave and sound content, as well as practice and evaluation questions, is structured in such a way that it is easy for teachers and students to use. The stages of developing this interactive media are as follows.

Analysis Stage

The first step of the analysis phase is problem analysis by observing students at school, it is revealed that students have difficulty solving questions involving vibration, wave, and sound material. In addition, students are less involved when they study. Based on the findings of the needs analysis, educators need learning tools that can encourage student participation. Utilizing computer-based media is one of them. The next step is curriculum analysis to ensure the basic competencies (KD) and core competencies (KI) that need to be developed.

Design Stage

The researcher made the initial design of interactive media at this design stage in the form of a display design with a title page, login page and main menu page. After that, arrange the layout of teaching materials and collect various images to improve the appearance of the media. From the main menu page, the media will be further developed into competency pages, materials, animations, exercises, evaluations, profiles, and instructions. The visual basic for application (VBA) used in this interactive media is already in microsoft powerpoint by activating the developer menu so there is no need to download the visual basic application again.

The developed interactive media contains material on vibrations, waves and sound and has been adapted to KD which are arranged as markers. Students can also work on practice and evaluation questions in this interactive learning media. At the end of each exercise and evaluation question, students can immediately find out the value they got. Researchers also prepared test questions, validation questionnaires, and student response questionnaires as part of this stage.

Development Stage

In his stage, the researcher developed an interactive microsoft powerpoint based media based on visual basic for application by including the necessary components such as pictures and materials. Interactive media display can be seen in Figure 1. Furthermore, programming (coding) is added as shown in Figure 2.

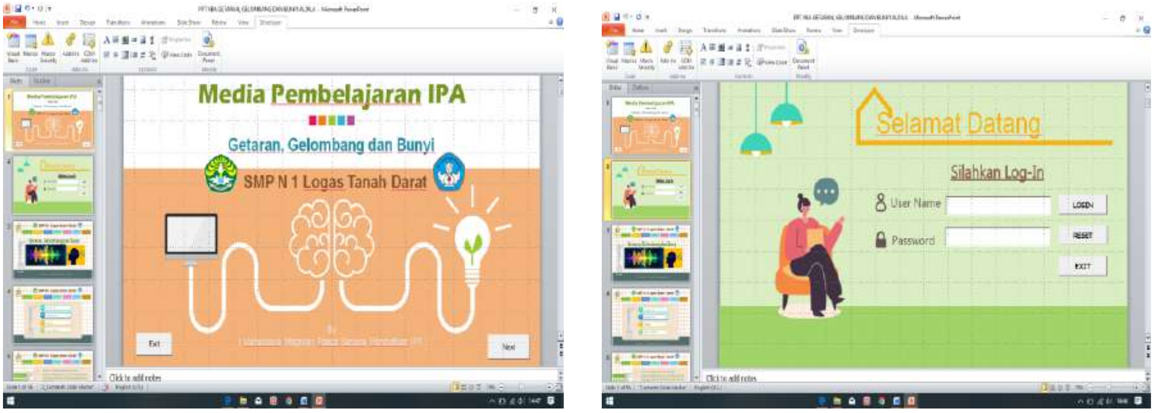

Figure 1. Interactive Media Display

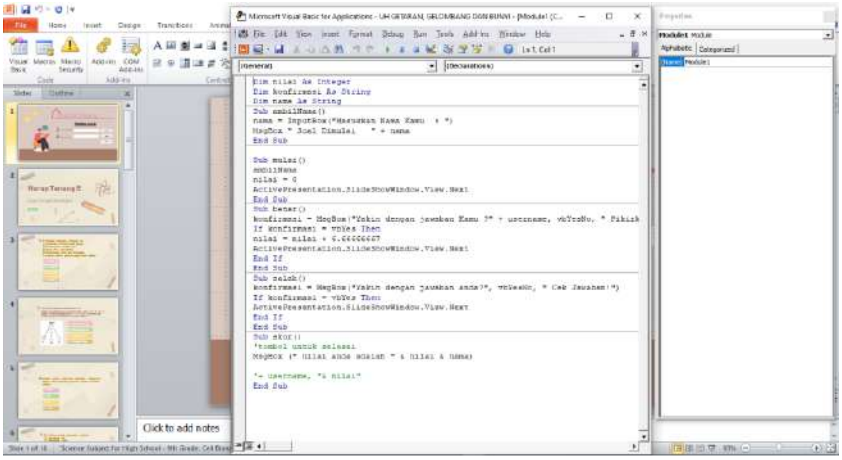

Figure 2. Media Coding Display

As for some of the parts contained in the developed media will be shown as follows :

a. Title Page

The title page is the initial appearance of interactive media which contains the university logo, school logo, material discussed in interactive media, school name, next button and exit button. The initial appearance of the media can be seen in Figure 3.

Figure 3. Title Page Display

b. Login Page

The login page display consists of a welcome greeting, please login, username, password, login button, next button and exit button, as shown in Figure 4.

Figure 4. Login Page Display

c. Main Menu Page

The main menu page consists of competency buttons, material buttons, animation buttons, practice buttons, evaluation buttons, profile buttons and hint buttons. There is also a home button to return to the main menu page. The main menu page display can be seen in Figure 5.

Figure 5. Main Menu Page Display

d. Competency Page

This page contains KI, KD, indicators and learning objectives. On the competency page the home button is used to return to the main menu page. The display of competency pages can be seen in Figure 6.

Figure 6. Competency Page Display

e. Material Page

On the material page there are material selection buttons, namely vibration, waves and sound. There are also back and forward buttons to continue to the next page or return to the previous page. The display of material pages from the media can be seen as Figure 7.

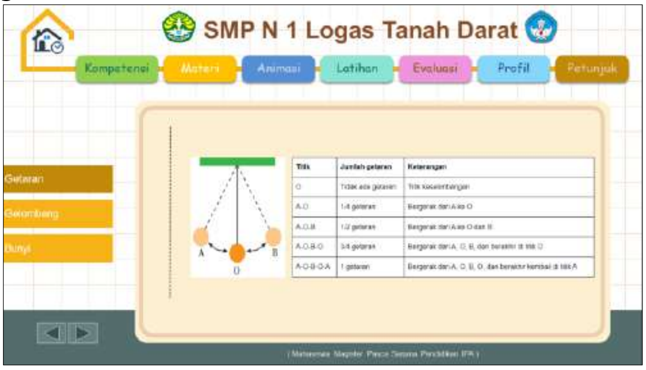

Figure 7. Material Page Display

f. Animation Page

The animation page contains moving animations about wave vibration and sound material. The animation page display can be seen in Figure 8.

Figure 8. Animation Page Display

Furthermore, there is a practice page which contains 3 sample questions for each sub-material accompanied by completion answers. Then the evaluation page contains daily test questions in the form of multiple choices of 15 questions. In addition, evaluation questions in interactive media can be done by students and at the end of completing the problem, students can see the scores obtained directly. Then there is a profile page which contains photos and biographical data for making learning media. Finally, there is an instructions page which contains instructions for using microsoft powerpoint media based on visual basic for applications.

The next step is to validate the media that was developed before 2 science education lecturers at the University of Riau and 1 science teacher at SMPN 1 Logas Tanah Darat. In addition, revisions were made according to the comments and ideas provided by the validator. After the validation process is complete, which results in the media being deemed fit for use, the questionnaire filled out by the validator becomes the basis for validation data analysis. The results of the validation data analysis are presented in Table 6.

Table 6. Results of the Validity of Microsoft Power Point Media based VBA

Aspects	Questions	Aiken's Index	Category
Design	1-9	0.85	High validity
Pedagogic	10-19	0.89	High validity
Content	20-28	0.84	High validity
Technical	29-36	0.83	High validity

The results of the overall validity of the interactive media microsoft powerpoint based on visual basic for application are valid with the Aiken V validity index of 0.86, placing it in the high validity category. This is in line with the theory put forward by Anomeisa & Ernaningsih (2020) which states that the PowerPoint media developed meets competency and content standards for the use of technology, so it is valid and appropriate for education. This interactive media is made as attractive as possible by combining text, images and videos. Also equipped with quizzes and navigation buttons that students can use directly to help them learn on their own (Sajeev et al., 2021; Wulandari & Nana, 2021). Students more easily understand learning by combining learning media components, such as printed teaching materials, images, audio, and video (Havizul, 2019; Nuraini et al., 2021).

The advantages of the interactive media developed are illustrated with examples and animations, including material on vibrations, waves and sound. Through the pictures presented, the goal is for students to gain contextual understanding. According to Havizul (2019), good learning media is presenting content interactively and visually, allowing students to see abstract subtopics concretely. In addition, practice questions are included in the media to measure students' understanding of the material.

The contents of the material in interactive media are arranged according to the K-13 syllabus, basic competency (KD), and instructions according to the learning objectives. The link between KD, indicators, learning objectives, and the suitability of evaluation with learning objectives can facilitate students and teachers in the learning process. So that learning objectives can be achieved properly (Dwiqi et al., 2020; Siddiq et al., 2020). This is consistent with previous research which found that in making learning media, it is very important to consider the appropriateness of learning objectives, indicators, basic competencies, and learning materials that students want to achieve (Dewi & Negara, 2021; Geni et al., 2020).

Students will learn more easily when interactive media is used in learning activities because it can be used according to student preferences. Through interactive media students can study independently at any time and from any location (Elwi et al., 2017; Gama et al., 2016; Kurniawati & Nita, 2018).

Implementation Stage

At this stage, trials were carried out in class VIII A. After students learned using interactive media microsoft powerpoint based on visual basic for applications on vibration, waves and sound material, each student was given a student response questionnaire about how to use interactive media in study activities. The results of the student response questionnaire data analysis can be seen in Table 7.

Table 7. Results of Student Response Data Analysis

Aspects	Questions	Practicality Level (%)	Category
Content Quality	1-5	77.60	Practical
Engineering Quality	6-9	90.50	Very Practical
Quality of learning	10-13	82.50	Very Practical
Efficiency	14-16	84.00	Very Practical

Based on the results of the analysis of student responses with an achievement score of 666 and a total of 10 students, an average percentage of 83.25 was obtained. In accordance with the practicality criteria, if the average score of the percentage of student responses is > 80%, the interactive media developed is in the very practical criteria. Therefore, microsoft powerpoint interactive media based on visual basic for applications on vibration, wave and sound material is declared practical. This is in line with the results of research conducted by Damayanti & Qohar (2019) which stated that microsoft powerpoint learning media based on visual basic for applications can foster students' passion for learning and make it easier for students to use it.

Between indicators, basic competencies, learning objectives, and material that are interrelated and evaluation with appropriate learning objectives can expedite learning activities so that they are able to increase students' knowledge (Dwiqi et al., 2020). In line with research (Hariyono & Darnoto, 2018) which states that mastery of learning media is a tool that can stimulate students to study so that the acquisition of knowledge in learning goes well.

Students are very enthusiastic in using learning media, because the appearance of the media is attractive and easy to operate, the text is read clearly, the selection of compositions and color combinations is right, besides that the media is supported by appropriate musical accompaniment so that microsoft powerpoint interactive media is based on visual basic for application can help students understand the material, and interactive media can increase student motivation in observing subject matter (Nurrita, 2018).

Using instructional media can help students and teachers understand concepts that have been systematically arranged (Darung et al., 2020). Selection of appropriate textual, animated, audio and video content can attract students' interest in acquiring knowledge and can increase the knowledge of students themselves (Khusniati, 2012). This microsoft powerpoint learning media can be used by students anytime and anywhere because this media is practical and does not require an internet connection. from the trial it can be concluded that microsoft powerpoint interactive media is feasible to use during the learning system. According to (Mansur & Rafiudin, 2020) states that the learning process will take place effectively and efficiently by using learning media.

When the learning media has been declared valid and practical, then field trials are carried out. Carry out field trials in class VIII B as many as 28 people to find out the effectiveness of the interactive media developed. After the learning process takes place using interactive media, students are asked to complete questions regarding vibration, wave and sound material. Then assess the learning outcomes and the number of students who score ≥ 68 (pass minimum completeness criteria (KKM).

The results of the analysis showed that 23 of the 28 students who passed the KKM got a completeness percentage of 82.14%. So, microsoft powerpoint interactive media based on visual basic for application on wave and sound vibration material is declared effective. This is in accordance with the results of research (Rahman & Mahmud, 2018) that power point learning media can increase students' learning activities in participating in learning activities.

The use of microsoft powerpoint interactive media based on visual basic for applications in learning can improve student learning outcomes because by using this media, students can more easily understand the material. This is in accordance with the results of research (Chotimah et al., 2018) that there are differences in student learning outcomes, namely learning outcomes using microsoft power point media based on visual basic for applications are better than classes that carry out ordinary learning. This is also in accordance with research (Nasution et al., 2020) that student learning outcomes increase after using learning media based on visual basic for application. This is also in line with the opinion (Octaviani, 2021) that microsoft powerpoint media based on visual basic for applications is easy for students to operate so that it can encourage students to be active and independent in learning activities with their own pattern and speed so as to improve learning outcomes learners.

Evaluation Stage

Based on the results of the development of microsoft power point interactive media based on visual basic for applications on vibration, wave and sound material, it was declared valid, practical and effective. This is consistent with the results of research according to (Faruq et al., 2018), namely the results of the development of microsoft powerpoint learning media based on visual basic for applications on arithmetic sequence material are declared valid, practical and effective. These results are supported by research which states that the developed microsoft powerpoint media is very suitable for use by students in learning science (Zulfadewina et al., 2020). Likewise with research which states that in the learning process microsoft powerpoint media is feasible to use and can improve student learning achievement (Fuad, 2019).

The advantages that exist from interactive media that are developed are displaying a variety of interesting features that can make students more enthusiastic about learning and make it easy for teachers in learning to convey material using these media. In addition, there is also research which states that the use of microsoft power point learning media can increase students' cognitive knowledge because there are pictures and sound shots that can be combined in microsoft power point (Anggara, 2019). There is also the same research which states that the results of the research show that the assessment of various aspects is in a proper category to be used as a learning medium (Sudarto et al., 2019).

Conclusion

Based on the results of this research, it can be concluded that the microsoft powerpoint interactive media based on visual basic for applications on vibration, waves, and sound material for class VIII students is valid

with an overall Aiken V validity index of 0.86. The results of students' practicality of using interactive media reached an average of 83.25%, which means that microsoft powerpoint interactive media based on visual basic for applications can be said to be practical. Student learning outcomes after using this interactive media reached a level of completeness (student scores ≥ 68 points) of 82.14%, so that the microsoft powerpoint interactive media based on visual basic for applications was considered effective. Thus it can be concluded that the microsoft power point interactive media based on visual basic for application vibration, wave and sound materials produced and developed are valid, practical and effective so that they are suitable for use in learning.

References

Aiken, L.R. 1980. Content validity and reliability of single items or questionnaires. *Educational and Psychological Measurement*, 40(4):955–959. https://doi.org/10.1177/001316448004000419.

Amatullah, N.S. 2021. Pengembangan e-modul berbasis android terintegrasi stem untuk meningkatkan keterampilan berpikir kritis siswa pada materi suhu, kalor dan perpindahan kalor SMA. *Tesis,* UIN Syarif Hidayatullah, Jakarta. https://repository.uinjkt.ac.id/dspace/handle/123456789/57402.

Andryansah, L.B., Kunayah, D., Fitri, A.A., Zubaidi, A., & Cahyani, V. 2021. Pengembangan media pembelajaran berbasis audio-visual 3-D materi. *PISCES Proceeding of Integrative Science Education Seminar Beranda*, 1, 325–332. https://prosiding.iainponorogo.ac.id/index.php/pisces/article/view/163.

Anggara, A.P. 2019. Pengembangan media pembelajaran powerpoint untuk meningkatkan kognitif dan kemampuan sosial anak usia dini. *Jurnal Teologi Berita Hidup*, 2(1):11–19. https://doi.org/10.38189/jtbh.v2i1.18.

Anomeisa, A.B. & Ernaningsih, D. 2020. Media pembelajaran interaktif menggunakan powerpoint VBA pada penyajian data berkelompok. *Jurnal Pendidikan Matematika Raflesia*, 5(1):17–31. https://doi.org/10.33369/jpmr.v5i1.10635.

Aprianty, D., Somakim, S., & Wiyono, K. 2021. Pengembangan multimedia interaktif pada pembelajaran matematika materi persegi panjang dan segitiga di sekolah dasar. *Sekolah Dasar: Kajian Teori dan Praktik Pendidikan*, 30(1):1-13. https://doi.org/10.17977/um009v30i12021p001.

Bashooir, K., & Supahar. 2018. Validitas dan reliabilitas instrumen asesmen kinerja literasi sains pelajaran fisika berbasis STEM. *Jurnal Penelitian dan Evaluasi Pendidikan*, 22(2):168–181. https://doi.org/10.21831/pep.v22i2.20270.

Bungawati, B., & Rahmadani, E. 2023. Development of powtoon based science learning media in Elementary Schools. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):265-275. https://doi.org/10.24815/jpsi.v11i2.27687.

Chan, F., Budiono, H., & Setiono, P. 2019. Pengembangan multimedia interaktif berbasis keterampilan proses dasar pada materi tumbuhan dan bagian-bagiannya di sekolah dasar. *ELSE (Elementary School Education Journal)*, 3(1):9–17. https://journal.um-surabaya.ac.id/index.php/pgsd/article/view/2330/1790

Chotimah, S., Bernard, M., & Wulandari, S.M. 2018. Contextual approach using VBA learning media to improve students' mathematical displacement and disposition ability. *Journal of Physics: Conference Series*, 948(1):1-10 https://doi.org/10.1088/1742-6596/948/1/012025.

Damayanti, P.A., & Qohar, A. 2019. Pengembangan media pembelajaran matematika interaktif berbasis powerpoint pada materi kerucut. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 10(2):119–124. https://doi.org/10.15294/kreano.v10i2.16814.

Darung, A., Setyasih, I., & Ningrum, M.V.R. 2020. Pengembangan media pembelajaran geografi menggunakan poster infogrfis. *Geoedusains: Jurnal Pendidikan Geografi*, 1(1):27–41. https://doi.org/10.30872/geoedusains.v1i1.183.

Dewi, C., Yanto, D.T.P., & Hastuti, H. 2020. The development of power electronics training kits for electrical engineering students: a validity test analysis. *Jurnal Pendidikan Teknologi Kejuruan*, 3(2):114–120. https://doi.org/10.24036/jptk.v3i2.9423.

Dewi, N.M.L.C. & Negara, I.G.A.O. 2021. Pengembangan media video animasi IPA pada pokok bahasan sistem pernapasan kelas V. *Jurnal Edutech Undiksha*, 9(1):122–130. https://doi.org/10.23887/jeu.v9i1.32501.

Dewi, S.R., & Haryanto, H. 2019. Pengembangan multimedia interaktif penjumlahan pada bilangan bulat untuk siswa kelas IV sekolah dasar. *Premiere Educandum : Jurnal Pendidikan Dasar dan Pembelajaran*, 9(1):9-22. https://doi.org/10.25273/pe.v9i1.3059.

Dwiqi, G.C.S., Sudatha, I.G.W., & Sukmana, A.I.W.I.Y. 2020. Pengembangan multimedia pembelajaran interaktif mata pelajaran IPA untuk siswa SD kelas V. *Jurnal Edutech Undiksha*, 8(2):33-48. https://doi.org/10.23887/jeu.v8i2.28934.

Elwi, L.C., Festiyed, & Djamas, D. 2017. Pembuatan lembar kerja peserta didik (LKPD) multimedia interaktif menggunakan course lab berbasis pendekatan saintifik pada pembelajaran fisika kelas X SMA/MA. *Pillar of Physics Education*, 9(1):97–104. http://dx.doi.org/10.24036/2521171074.

Ernawati, Kristiana, M.A., & Safitri, S.Y. 2022. Pengembangan pembelajaran media interaktif menggunakan visual basic application for powerpoint untuk pembelajaran fisika SMA pada materi listrik arus searah. *Seminar Nasional Hasil Riset dan Pengabdian*, p.440–447. https://snhrp.unipasby.ac.id/prosiding/index.php/snhrp/article/view/346.

Faruq, F., Dafik, Suharto, Fatahillah, A., & Murtikusuma, R.P. 2018. Pengembangan media pembelajaran interaktif online pokok bahasan barisan aritmetika berbantuan microsoft visual basic. *Kadikma* 9(2):89–96. https://doi.org/https://doi.org/10.19184/kdma.v9i2.9751.

Firmansyah, F.H., Fajriyah Aldriani, S.N., & Dewi, E.R. 2020. Pengembangan multimedia pembelajaran interaktif untuk mata pelajaran matematika untuk kelas 5 sekolah dasar. *Edsence: Jurnal Pendidikan Multimedia*, 2(2):101–110. https://doi.org/10.17509/edsence.v2i2.29783.

Fuad, A.J. 2019. Pemanfaatan media slide power point dalam meningkatkan prestasi siswa. *El-Bidayah: Journal of Islamic Elementary Education*, 1(1):61–77. https://doi.org/10.33367/jiee.v1i1.683.

Gama, I.G.B.S., Mahadewi, L.P.P., & Jampel, I.N. 2016. Pengembangan multimedia tutorial interaktif sumber daya alam dan teknologi pada mata pelajaran IPA kelas IV di SDN 3 Banyuasri. *Jurnal Edutech*, 6(3):1–10. https://doi.org/10.23887/jeu.v4i1.20209.

Geni, K.H.Y.W., Sudarma, I.K., & Mahadewi, L.P.P. 2020. Pengembangan multimedia pembelajaran interaktif berpendekatan CTL pada pembelajaran tematik siswa kelas IV SD. *Jurnal Edutech Undiksha*, 8(2):1-16. https://doi.org/10.23887/jeu.v8i2.28919.

Hariyono, M., & Darnoto. 2018. Pengembangan media interaktif geokolase information and comunication tecnologies (ICT). *Jurnal Pendidikan Matematika*, 1(1):41–51. http://dx.doi.org/10.21043/jpm.v1i1.4456.

Havizul, H. 2019. Pengembangan multimedia interaktif untuk pembelajaran IPS di sekolah dasar menggunakan model DDD-E. *Sosial Horizon: Jurnal Pendidikan Sosial*, 6(2):283-297. https://doi.org/10.31571/sosial.v6i2.1202.

Husna, N., Sari, S.A., & Halim, A. 2017. Pengembangan media puzzle materi pencemaran lingkungan di SMP Negeri 4 Banda Aceh. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 5(1):66-71. https://jurnal.usk.ac.id/JPSI/article/view/8413.

Ibrahim, I., Gunawan, G., & Kosim, K. 2020. Validitas perangkat pembelajaran fisika berbasis model discovery dengan pendekatan konflik kognitif. *Jurnal Pijar Mipa*, 15(3):214–218. https://doi.org/10.29303/jpm.v15i3.1878.

Khusniati, M. 2012. Pendidikan karakter melalui pembelajaran matematika. *Jurnal Pendidikan IPA Indonesia*, 1(1):204–210. https://doi.org/10.28918/jupe.v10i1.354.

Kurniawati, I.D. & Nita, S. 2018. Media pembelajaran berbasis multimedia interaktif untuk meningkatkan pemahaman konsep mahasiswa. *Doubleclick Journal of Computer and Information Technology*, 1(2):68-75. https://doi.org/10.25273/doubleclick.v1i2.1540.

Mansur, H. & Rafiudin, R. 2020. Pengembangan media pembelajaran infografis untuk meningkatkan minat belajar mahasiswa. *Jurnal Komunikasi Pendidikan*, 4(1):37-48. https://doi.org/10.32585/jkp.v4i1.443.

Maruti, E.S. 2016. Pengembangan media pembelajaran keterampilan menyimak dan membaca berbasis multimedia interaktif siswa kelas IV sekolah dasar. *Premiere Educandum : Jurnal Pendidikan Dasar dan Pembelajaran*, 5(1):49–58. https://doi.org/10.25273/pe.v5i01.324.

Mukmin, B.A. & Primasatya, N. 2020. Pengembangan multimedia interaktif macromedia flash berbasis K-13 sebagai inovasi pembelajaran tematik untuk siswa sekolah dasar. *Jurnal Pendidikan Dasar Nusantara*, 5(2):211–226. https://doi.org/10.29407/jpdn.v5i2.13854.

Mulyono, H., Darman, R.A., & Desriwandi, F. 2019. Pengembagan media pembelajaran interaktif pada mata pelajaran TIK di SMP N 2 Painan Provinsi Sumatera Barat. *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)*, 4(2):166-174. https://doi.org/10.29100/jipi.v4i2.1369

Muzanni, A. & Zinnurain, Z. 2018. Pengembangan multimedia interaktif permainan tradisonal berbasis character building pada peserta didik sekolah dasar. *Jurnal Ilmiah Mandala Education*, 4(2):210-215. https://doi.org/10.36312/jime.v4i2.477.

Namiroh, S. 2019. Pengembangan media interaktif berbasis komputer pada pembelajaran tematik kelas V sekolah dasar. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, 4(1):53–67. https://doi.org/10.23969/jp.v4i1.1587.

Nasir, M. 2017. Design and empirical analysis visualization motion and vector analysis program as interactive multimedia physics learning at. *Applied Science and Technology*, 1(1):240–247. http://www.estech.org.

Nasution, H.M. Sari, Yahfizham, & Maysarah, S. 2020. Pengembangan media pembelajaran VBA (visual basic application) for powerpoint pada materi segi empat di kelas VII MTs Lab IKIP UMN Al-Washliyah. *Axiom : Jurnal Pendidikan & Matematika*, 9(2):145–153. http://dx.doi.org/10.30821/axiom.v9i2.7976.

Nuraini, M., Susilaningsih, S., & Wedi, A. 2021. Pengembangan multimedia interaktif materi perubahan wujud benda bagi siswa Sekolah Dasar. *JKTP: Jurnal Kajian Teknologi Pendidikan*, 4(1):33–40. https://doi.org/10.17977/um038v4i12021p033.

Nurrita, T. 2018. Pengembangan media pembelajaran untuk meningkatkan hasil belajar siswa. *Misykat: Jurnal Ilmu-Ilmu Al-Quran, Hadist, Syari'ah dan Tarbiyah*, 3(1):171-187. https://doi.org/10.33511/misykat.v3n1.171.

Octafiana, W., Ekosusilo, M., & Subiyantoro, S. 2018. Pengembangan multimedia interaktif pada materi pesawat sederhana untuk siswa Sekolah Dasar. *Jurnal Komunikasi Pendidikan*, 2(2):168-175. https://doi.org/10.32585/jkp.v2i2.131.

Octaviani, S.W. 2021. Pengembangan media pembelajaran powerpoint interaktif berbasis scientific approach pada pembelajaran IPA di kelas IV Sekolah Dasar. *ETJ (Education Technology Journal)*, 1(2):66–77. https://doi.org/10.26740/etj.v1n2.p66-77.

OECD. 2019. *PISA 2018 : PISA Result In Focus*.

Pratiwi, E.D., Hutahaean, S.D., Bustan, A., & Dinata, P.A.C. 2022. Analisis kesulitan siswa dalam menyelesaikan soal pada materi getaran dan gelombang di kelas VIII MTs Negeri 1 Palangka Raya. *Journal of Banua Science Education*, 2(2):85–92. https://doi.org/10.20527/jbse.v2i2.101.

Rahman, M., & Mahmud, N. 2018. Pengaruh penggunaan media pembelajaran powerpoint terhadap hasil belajar matematika peserta didik kelas X SMA Negeri 3 Majene. *Saintifik*, 4(1):83–92. https://doi.org/10.31605/saintifik.v4i1.147.

Rahmawati, N.R., Rosida, F.E., & Kholidin, F.I. 2020. Analisis pembelajaran daring saat pandemi di Madrasah Ibtidaiyah. *Sittah: Journal of Primary Education*, 1(2):139–148. https://doi.org/10.30762/sittah.v1i2.2487.

Rambe, N.R. & Saragih, A.H. 2016. Developing learning media of tenses based on interactive multimedia for elementary school students. *Jurnal Teknologi Informasi & Komunikasi Dalam Pendidikan*, 3(2):13-22. https://doi.org/10.24114/jtikp.v3i2.5015.

Ratnasari, D., Oktaviyanti, D., Sukmawati, S.S., & Setiyawati, E. 2020. Pengembangan mobile learning berbasis program APPYPIE untuk pembelajaran fisika. *Jurnal Penelitian Pendidikan Fisika*, 5(2):158-163.https://doi.org/10.36709/jipfi.v5i2.13149.

Sajeev, M.F., Kelada, L., Yahya, N.A.B., Wakefield, C.E., Wewege, M.A., Karpelowsky, J., Akimana, B., Darlington, A.S., & Signorelli, C. 2021. Interactive video games to reduce paediatric procedural pain and anxiety: a systematic review and meta-analysis. *British Journal of Anaesthesia*, 127(4):608–619. https://doi.org/10.1016/j.bja.2021.06.039.

Siddiq, Y.I., Sudarma, I.K., & Simamora, A.H. 2020. Pengembangan animasi dua dimensi pada pembelajaran tematik untuk siswa kelas III sekolah dasar. *Jurnal Edutech Undiksha*, 8(2):49-63. https://doi.org/10.23887/jeu.v8i2.28928.

Sintya, Y.R., Sutadji, E., & Djatmika, E.T. 2020. Pengembangan multimedia interaktif pada pembelajaran tematik kelas V sekolah dasar. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 5(8):1105-1114. https://doi.org/10.17977/jptpp.v5i8.13905.

Sofwan, M. & Wibowo, M.B.E. 2019. Pengembangan multimedia interaktif berbasis unity pada subtema keberagaman budaya bangsaku di kelas IV sekolah dasar. *Jurnal Gentala Pendidikan Dasar*, 4(2):201–208. https://doi.org/10.22437/gentala.v4i2.8438.

Soimah, I. 2018. Pengaruh media pembelajaran berbasis komputer terhadap hasil belajar IPA ditinjau dari motivasi belajar siswa. *Natural: Jurnal Ilmiah Pendidikan IPA*, 5(1):38-44. https://doi.org/10.30738/natural.v5i1.2559.

Sudarto, Nugrahani, F., & Susanto, H.A. 2019. Pengembangan bahan ajar media audio visual berbasis powerpoint untuk menumbuhkan minat membaca permulaan sekolah dasar. *Journal of Chemical Information and Modeling*, 1(1):1689–1699. https://doi.org/10.32585/.v5i1.615.

Sugiyono. 2019. *Metode Penelitian & Pengembangan (Research and Development)*. Alfabeta, Bandung.

Susanto, E. & Retnawati, H. 2016. Perangkat pembelajaran matematika bercirikan PBL untuk mengembangkan HOTS siswa SMA. *Jurnal Riset Pendidikan Matematika*, 3(2):189–197. https://doi.org/10.21831/jrpm.v3i2.10631.

Wafiq, K., Rosyid, H., Kristari, A., & Sukmana, F. 2021. Pengembangan media pembelajaran game edukasi berbasis android pada mata pelajaran fisika dengan model prototype. *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)*, 6(2): 448-456. https://doi.org/10.29100/jipi.v6i2

Wirangga, C., Ahda, Y., & Arsih, F. 2018. Development of interactive multimedia based on power point at fluid preasure material and implementation in life; for junior high school students. *Bioeducation Journal*, 2(2):168–177. https://doi.org/10.24036/bioedu.v2i2.101.

Wulandari, S. & Nana. 2021. Studi literatur penggunaan PBL berbasis video untuk meningkatkan kemampuan pemecahan masalah. *JPF (Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, 9(1):7-17. https://doi.org/10.24252/jpf.v9i1.13818.

Wulandari, Y., Ruhiat, Y., & Nulhakim, L. 2020. Pengembangan media video berbasis powtoon pada mata pelajaran IPA di kelas V. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(2):269-279. https://doi.org/10.24815/jpsi.v8i2.16835.

Yanto, D.T.P. 2019. Praktikalitas media pembelajaran interaktif pada proses pembelajaran rangkaian listrik. *Invotek: Jurnal Inovasi Vokasional dan Teknologi*, 19(1):75–82. https://doi.org/10.24036/invotek.v19i1.409.

Zulfadewina, Ninawati, M., Rahmiati, & Husain, Z.M. 2020. Pengembangan media audio visual berbasis microsoft power point siswa kelas 5 SD. *Jurnal Riset dan Inovasi Pendidikan Dasar*, 1(1):38–48. https://jurnal.stkippgritrenggalek.ac.id/index.php/tanggap/article/view/41.

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Identification the 2013 Curriculum Teacher's Book to Determine the Character Values of Class X Students on Circular Motion Material

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Abstract. The character of school students is currently in the declining category. This is due to the lack of emphasis on the time of the learning process and affects the level of success of the functions and objectives of national education. This study aims to determine the characters that are not embedded in the physics learning process for class X material for circular motion. The research method used is a qualitative method with the type of documentation research. The researcher uses a documentation study because the subject used is a 2013 curriculum teacher's book for class X circular motion. After studying the circular motion material, it is known that there are 18 characters that must be instilled during the physics learning process. However, these 18 characters are not fully embedded because there are some characters that are missing and will have a continuous negative impact on students. Due to the imperfection of this research, in the future, in the textbook of physics learning teacher class X on Circular Motion in the 2013 curriculum and its subsequent development, more attention should be paid to the character of students so that all these characters are fulfilled in order to create a good generation.
Keywords: Character, Learners, Physics Learning

Introduction

Education is a process focused on the academic and social-emotional needs of gifted and high-potential learners who have a purpose (Phelps & Lewis, 2015; Pratama, Firman & Neviyarni, 2019; Hermana et al., 2021). To achieve the goals of education, a learning process is needed. Learning is a series of activities of the body soul to obtain a change in behavior as a result of the experience of the individual in interaction with his environment that concerns cognitive, affective and psychomotor (Sari & Wulandari, 2020; Ahamad et al., 2021; Arkhipova & Podshivalova, 2021). The affective realm includes five levels of ability, namely receiving, answering, or reacting, assessing, organization and characterization with a value or value complex (Andriani & Rasto, 2019; Sanborn, 2023). The aspects that need to be instilled make the brain work hard and its priority to learn.

To achieve these results, we need to think deeply about how we want to reshape organizations to learn about sustainability, in what terms and why. We must ask: Who is responsible and how do we ensure the inevitable learning is long lasting (Alfauzan & Tarchouna, 2017; Falsarone, 2022; Stewart, 2022). This means that all related subjects need to think about the learning objectives for the next continuity, not just for now the learning objectives must always be continued and even the results can be developed with their education, achievements, and creativity; and, above all, the grounding and stabilization that they provide at the emotional, mental, and family levels (Meier et al., 2021; Karatas & Aktan, 2022). Basically the goal of achieving cognitive, affective, and psychomotor aspects of learning method used also adjusts the subject matter or material (Luszczynska, 2021; Maureen et al., 2022). In order not to overlap in its achievement, it is divided into each subject at each level of education.

This level of education is prepared to distinguish the way teachers assess each related aspect. This is done to realize and its relationship to primary, secondary and tertiary education (Glerum et al., 2020; Scott & Bajaj, 2023). Thus, the way education systems are providing vocational education and training depends on the combination of school and work-based education (Vugt et al., 2022; Yilmaz et al., 2021). In the realm of education, preparation for the world of work, it is necessary to have increased investment in quality education to ensure that there is a sufficient pool of skilled people (Ava, 2020; Teo et al., 2022). A new era of physics encompasses the progress that has been made in the past half-century in understanding the weak, electromagnetic, and strong interactions to the basic facts of physics are available elsewhere (Jalinus et al., 2019; Setiaji & Dinata, 2020; Bare & Sari, 2021). Physics also deals with the structure of everyday life and binds to substances, particles, forces, efforts, and so on.

Especially in physics learning which includes things that occur in life, many of the previous studies have expressed their opinions about physics. Learning in physics education leads to the teaching of abstract and complex physics topics such as force and motion, learning theory, and pedagogy in relation to the teaching of physics (Nordin & Osman, 2018; Ahamad et al., 2021; Saudelli et al., 2021). To assist in physics learning, teachers and related parties prepare textbooks to support curriculum improvement in physics education (Mustu & Sen, 2019). One of them, physics laboratory experiments using a computer interface experiments set that provide real-time results are interesting and effective experiments in student supervision (Demircioglu, 2022; Fatmaryanti et al., 2022; Sukmak & Musik, 2022). This shows that facilities and infrastructure, learning methods, learning models play an important role in the education system.

In every aspect related to the realm of education there are several shortcomings that cannot be denied. This is shown in the high school teacher's book class X curriculum 2013 circular motion material, there are still character values that are not embedded. The characters are religious, tolerance, honesty, disciplines (Mayer & Wet, 2018; Hackmann et al., 2022). The next character value is creative, strive, care for the environment, social care (Gerard et al., 2021; Skoglund et al., 2022). Furthermore, character values that need to be instilled during the learning process are respect for achievements, peace-loving, homeland-loving, responsible, independent, democratic, friendly/communicative, fond of reading (Hatchimonji et al., 2022; Hibbert, 2021; Jorgensen, 2023). From the 18 character values, the researcher took several characters that will be discussed, these characters are religious, national spirit, love of homeland, cherish achievements, peace-loving, environmental care, social care.

Research on the analysis of character values in physics learning that has been carried out by Putri et al. (2019); Ong (2022); Wong (2020), explained that education plays an important role in developing the potential of students, so that students have the character and skills needed to contribute to the world of education and globally. Therefore, character education is needed from an early age to become the initial foundation of the younger generation in responding to the current era of progress. Such character education will provide a good and advanced generation. This has caused researchers to be interested in identifying the negative impacts due to the ingravation of some character values, especially in physics learning.

This research was conducted with the aim of being able to find out the negative impact of not attaching character values to circular motion material. The character values in question are religious, national spirit, love for the motherland, respect for achievement, love for peace, care for the environment, care for the social. Well, this is the formulation of the main problem that will be discussed by researchers. This could become an ongoing problem that not only affects circular motion matter but other physical matter would also be affected, due to the absence of a foundation in the first place. With this research, it is hoped that the characters that appear in students can really be identified properly. Therefore, this study aims to examine physics teacher's books to determine the impact of character values that are not instilled in students.

Methods

The research method used is a qualitative method. The type of research is in the form of a documentation study by collecting data from documents such as books, journals, photos, videos. This qualitative research aims to explain a phenomenon as deeply as possible by collecting data as deeply as possible, which shows the importance of the depth and detail of the data studied.

The sampling technique in this study was to study the physics teacher's book for class X on circular motion. The variable taken is the character of students who are not contained in the book. Character variables that were not found were religious, national spirit, love for peace, love for the motherland, care for the environment, care for social, appreciate achievement.

With the research instrument used is documentation. A document is a record of an event that has passed. Documents can be in the form of writings, drawings, or monumental works of a person (Thalib, 2022). In this study, researchers used documentation studies by collecting literature that was relevant to the topic under study. The physics teacher's book curriculum 2013 class X SMA circular motion material is the main document that will be reviewed first and a reference from the relevant previous research.

The data analysis technique used was document analysis, the teacher's book was reviewed first to identify some character values that were not found in the high school physics teacher's book on circular motion material and mapped it out in table 2, by grouping several aspects analyzed, namely the content of the material, questions and assignments. After searching for relevant literature and case sources, in the teacher's book which was reviewed by analyzing the content of the material, questions, and assignments, 18 characters were obtained that had to be instilled during the learning process. Then the characteristics of students who are not embedded in learning will be discussed by linking them to relevant previous research. Data collection procedures carried out in the form of literature study. This literature review is different from a literature review, carried out by reviewing written sources in the form of documents, namely books and reinforced by relevant relevant sources. The first activity carried out is to explore the characters that are and are not found in content analysis, question analysis, and task analysis. Furthermore, the characters that were not found were identified as the impact that occurred on students, to support this, the researcher collected documents and references in the form of books and journals related to the research.

Results and Discussion

The character of students is currently decreasing along with the advancement of the era which has an impact on the field of education. According to the opinion of Baehaqi & Murdiono (2020); Hermino & Arifin (2020); Hidayati et al. (2020), there are 18 student characters that are important to instill in the learning process, namely religious, tolerance, discipline, honest, hard work, independent, love peace, love the motherland, care for the environment, care socially, respect achievement, democracy, communicative/friendly, love to read, curiosity, national spirit, creativity, and responsibility. Character values are very important in the learning process because they help shape one's personality and personality (Sopacua et al., 2020). In addition to academic knowledge, character values help develop social skills, ethics, responsibility, integrity, discipline, cooperation and perseverance (Pamungkas et al., 2021; Sadykhan et al., 2022; Zaim et al., 2020). According to Bare & Sari (2021); Jamaluddin et al. (2022); Suyitno et al. (2019), here are some reasons why character values are important in the learning process:

1. Moral and ethical formation: Character values help students develop an understanding of what is right and wrong. They help students understand the importance of integrity, honesty and responsibility in all aspects of life.
2. Develop social skills: Values such as cooperation, empathy, respect for differences, and effective communication help students build healthy relationships with their peers. This is important for working together in groups, solving problems together, and creating an inclusive learning environment.
3. Encouraging discipline and responsibility: Character values help students understand the importance of discipline, persistence, and responsibility in achieving their goals. They help students learn to manage their time, work hard, and overcome challenges that may arise in the learning process.
4. Forming a positive personality: Learning character values helps to form a positive personality and prepares students to face the real world. They help students develop a positive attitude, optimism, fortitude, and mental toughness in the face of life's challenges.
5. Improving the quality of life: Character values are not only relevant in educational contexts, but also in everyday life. Establishing strong character values helps students become better individuals, which influences relationships with others, personal success, and overall happiness.

In order to support the formation of character values, schools and educators can implement learning strategies that involve discussions, role modeling, collaborative projects, and provide constructive feedback on student behavior. Character values have a very important role in the curriculum. Bringing character values into the curriculum helps students develop the attitudes, skills, and values that are important for their lives outside of school (Komalasari & Saripudin, 2018; Montessori et al., 2021). According to Ozkan & Umdu (2021); Rosa et al. (2021); Wahjusaputri & Nastiti (2022), here are some reasons why character values are important in the curriculum:

1. Formation of a balanced personality: A curriculum that includes character values assists students in building a balanced personality. They learn about the importance of social skills, ethics, integrity and responsibility. Thus, the curriculum can help students become individuals who are responsible, ethical, and have high social sensitivity.
2. Facing the real world: Students need to prepare themselves to face the diverse and complex real world. A curriculum that integrates character values helps students

understand the consequences of their actions, consider their impact on others, and develop good attitudes towards the environment around them.

3. Build social skills: A curriculum that includes character values helps students develop the social skills needed to interact with others effectively. They learn about cooperation, effective communication, joint problem solving, and respect for differences. These social skills will come in handy in their future personal and professional lives.
4. Strengthen positive attitudes: A curriculum that teaches character values can help students strengthen positive attitudes, such as optimism, perseverance, and mental toughness. When students learn about the importance of facing challenges with a positive attitude, they become better able to overcome obstacles and stay motivated to achieve their goals.
5. Forming good citizens: A curriculum that promotes character values helps students understand and appreciate the values of democracy, human rights, justice, and active participation in society. They learn to be responsible citizens, be aware of social issues, and contribute to positive change in their communities.

Integrate character values into the curriculum, it is important to develop and implement teaching strategies that include direct experience, reflection, role modeling, and relevant and contextual learning. In addition, involving parents and the community in learning character values can also strengthen the implementation of these values in students' daily lives. In the 2013 high school physics teacher's book, the circular motion material obtained is arranged in table 1. What is covered in table 1 can be seen that there are several aspects that are analyzed, namely the content of the material, questions, and tasks. Look at table 1, there are 18 characters that need to be instilled in the learning process of physics class X curriculum 2013 circular motion material. The three aspects analyzed will see characters that are embedded or not embedded during the learning process of physics of circular motion material.

Table 1. Results of Identification of Character Values of Circular Motion material

Character	Analysis		
	Content (Materials)	Question	Task (Projects)
Religious			
Honest	(110)	(111, 112, 113)	
Tolerance	(110, 111, 113)		(116)
Discipline	(111, 113)	(111, 112)	(116)
Strive	(110, 111, 112, 113)	(111, 112, 113, 114)	(116)
Creative	(112)		(116)
Self-sufficient	(110, 111, 113)	(110, 112, 113, 114)	(116)
Democratic	(110, 113)		(116)
Curiosity	(109, 110, 111, 112, 113)	(111, 112, 113, 114)	(116)
National Spirit			
Love of the Motherland			
Rewarding Achievements			
Friendly/Communicative	(110, 112)		(116)
Peace-Loving			
Love to Read	(110, 112)	(111, 112)	(116)
Caring for the Environment			
Social Care			
Responsibility	(110, 112, 113)	(111, 112, 113, 114)	(116)

In Table 1 which has presented character values grouped in the material content, questions, and assignments section, there are 18 character values that need to be achieved when learning physics in circular motion material are religious, honest, tolerance, hard work, care for the environment, social care, love for the homeland, love for peace, national spirit, love to read, democratic, responsibility, discipline, creative, appreciate achievement, communicative. For character values that are not achieved, it can be seen in Table 2. Character values that are not achieved are what will be discussed in this study.

Table 2. Results of identification of unembedded character values in circular motion material

Character	Analysis		
	Content (Materials)	Question	Tasks (Projects)
Religious	not embedded	not embedded	not embedded
National Spirit	not embedded	not embedded	not embedded
Love of the Motherland	not embedded	not embedded	not embedded
Rewarding Achievements	not embedded	not embedded	not embedded
Peace-Loving	not embedded	not embedded	not embedded
Caring for the Environment	not embedded	not embedded	not embedded
Social Care	not embedded	not embedded	not embedded

After being mapped based on aspects of material content, questions, and project tasks. There are 7 characters that are not embedded in the material of circular motion. These character values can be seen in Table 2, which includes character values that are not embedded are religious, national spirit, love of homeland, respect for achievements, peace-loving, environmental care, and social care.

After looking through Table 1, there are 18 characters that must be instilled in the learning process in order to create good character for each student. As written in the national education system law number 20 of 2003 explains that the function of national education is to develop abilities and form a dignified national character and civilization in order to educate the nation's life, aims to develop the potential of students to become human beings who have faith and piety in god almighty, have a noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens (Nasution, 2018). In line with the opinion of Nasution, there are several pillars of character that must be instilled in students, namely the love of god and all His creation, independence and responsibility, honesty or mandate and wisdom, respect and courtesy, benefactor, helpful and mutual aid, confident, creative, and hardworking, leadership and justice, kind and humble, as well as tolerance, peace and unity (Muslich, 2022).

By looking at the opinions of some of the previous authors, the characters that should be instilled are quite a lot and very important role in the present and subsequent lives. This is a tough challenge both from internal factors of students and also external factors. The student's internal factors can be his family environment, the student's mentality, and the drive to learn from himself (Anggraini et al., 2022). Meanwhile, external factors are his association with peers outside the home, school and the environment around the school (Husna et al., 2020). So that schools also play an important role in students' lives. To fulfill this role, the school provides teachers as educators to teach character education to students. Making people intelligent and smart, it may be easy to do, but making people to be good and wise people, seems much more difficult or even very difficult. Thus, it is very natural to say that moral problems are acute problems or chronic diseases that accompany human life whenever and wherever (Sudrajat, 2011). And this is a special concern in educational units.

In table 1 of the circular motion subsection, you can see eighteen character values that must be met in the material content, questions, and tasks are religious, honest, tolerance, discipline, hard work, creative, independent, democratic, curiosity, national spirit, love of the homeland, respect for achievements, friendly/communicative, peace-loving, fond of reading, environmental care, social care, and responsibility. Of the eighteen character values, there are 7 character values that are not embedded in the material content, questions, and project assignments that students have carried out on circular motion materials, namely religion, national spirit, love for the homeland, respect for achievements, peace-loving, environmental care, and social care. It is for this untreated character that it will cause a negative impact on the student.

The value of religious character is the most basic character in living life. Religious character is also related to religion, in the content of the material, questions, and assignments of the circular motion material project if the student is not directed to a religious character then when starting the lesson the student does not start the lesson by praying, ignoring religious norms which will also have an impact on his social relationship with other creations of god. When starting learning the teacher needs to direct his students to start by praying and expressing gratitude to god, because His blessings and graces classroom learning can be carried out as in previous days. If without His power how can the matter of circular motion proceed smoothly and how can the project be for example, the practicum is carried out well. Furthermore, introducing diversity to students can foster a spirit of student tolerance to better view existing differences more wisely. Teaches students that although others have different religions or tribes, human beings are actually the same and should not be discriminated against (Ridwan & Mudiono, 2017). Especially on the issue of diversity between students, it can also be related to social care and peace-loving. In the content section of the material, questions, and project assignments, if the character of social care and peace-loving is not embedded, the student will feel that he does not need other people. Meanwhile, in the circular motion material, students are required to interact with each other with their other friends. For example, in circular motion there are student projects that require students to work together, teamwork / group work. The teacher will divide the team/group between students and provide a topic of circular motion problems that will be discussed in each group, and students will work together to solve the topic of circular motion problems that have been given by the teacher. And it also encourages students to communicate well and create a social care and peace-loving character between students on circular motion material.

The application of the character of the spirit of nationality can usually be exemplified by the passion of the student to learn, the drive to achieve the goal in himself or herself. The spirit of nationality needs to be instilled so that students are encouraged to become real change as the goal and function of national education. In the circular motion material, part of the material content, questions, and project tasks does not have the character of the national spirit. This has a negative impact on the enthusiasm of students who will be lazy in learning circular motion material. For example, students will be lazy in understanding formulas, doing assignments and questions that have been given by the teacher, students tend to prefer to cheat on their friends without enthusiasm to complete tasks and circular motion material problems (Ardhuha et al., 2019). And at the time of group work students who are not instilled with the spirit of nationality will also underestimate their group and only accept it when the results are obtained. The spirit of nationality can also be directed through learning videos of circular motion materials that lead to the application of laws based on local wisdom. Local wisdom can be illustrated by the circular motion formula on tractor tires in rice fields.

The implementation of character values that are not embedded next in the content section of the material, questions, and tasks is to care for the environment and love the homeland. The value of such characters will have a negative impact if it is not embedded in the material of circular motion. This can be shown by the absence of the application of circular motion experimental tools based on local wisdom such as circular motion on the wheels of rice tractors. Physics learning only relies on simulations from foreign sources which are less effective because they are not carried out directly (Ramdani & Artayasa, 2020; Zulfa & Haryanto, 2021). And the implementation of the character of appreciating achievements that are not embedded in circular motion material is that students will not appreciate the work of friends who have tried to find solutions or solutions to project tasks such as practicums or experiments. This refers to the nature of plagiarism which is simply plagiarizing, cheating, copying a friend's property without thinking about the effort his friend has made in finding answers to the topic of circular motion material. It can be predicted that this continuous impact will make students know nothing about circular motion material both in formulas and theory.

Research on the analysis of character values in physics learning that has been carried out by (Putri et al., 2019; Ong, 2022; Wong, 2020), explained that education plays an important role in developing the potential of students, so that students have the character and skills needed to contribute to the world of education and globally. In the previous researchers, character development was needed to contribute to the achievement of educational goals and functions. Therefore, character education is needed from an early age to become the initial foundation of the younger generation in responding to the current era of progress. Such character education will provide a good and advanced generation. This character is important because it is intertwined with the morals and ethics of each individual. This has caused researchers to be interested in identifying the negative impacts due to the indefiniteness of some character values, especially in physics learning.

To overcome these negative impacts, a comprehensive evaluation of each related subject is carried out such as teachers, students, the surrounding environment, and the government. Integration can be carried out in the substance of the material, learning approaches and methods, as well as the developed evaluation model (Khoiriyah et al., 2021). Not all the substance of the subject matter is suitable for all the characters to be developed, it needs selection of the material and synchronization with the character to be developed. In principle, all subjects can be used as a tool to develop all the characters of learners, but in order not to overlap and neglect one of the characters to be developed, it is necessary to carry out mapping based on the proximity of the material to the character to be developed. The integration of character education can not only be done in the subject matter, but teaching techniques and methods can also be used as a tool for character education.

Conclusion

The results showed that the physics teacher's book on the 2013 curriculum material for class X SMA still had a lot of character values that were not included in the learning process. Characters that are not embedded are religious, national spirit, love for the motherland, respect for achievement, love for peace, care for the environment and care for the community. These missing characters will have a negative impact on students because the 2013 curriculum must have 18 characters. For this reason, it is hoped that in the future the physics teacher's book in high school can have all the characters and can be applied to produce a better generation.

References

Ahamad, A.N.. Samsuddin, M.A., Ismail, M.E., & Ahmad, N.J. 2021. Enhancing the achievement in physics motion concept through online multiple intelligence learning approach. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(2):1–11. https://files.eric.ed.gov/fulltext/EJ1289591.pdf.

Alfauzan, A.A. & Tarchouna, N. 2017. The role of an aligned curriculum design in the achievement of learning outcomes. *Journal of Education and e-Learning Research*, 4(3):81–91. https://files.eric.ed.gov/fulltext/EJ1155827.pdf.

Andriani, R. & Rasto, R. 2019. Motivasi belajar sebagai determinan hasil belajar siswa. *Jurnal Pendidikan Manajemen Perkantoran*, 4(1):80-86. Doi:10.17509/jpm. v4i1.14958. https://ejournal.upi.edu/index.php/jpmanper/article/ view/14958

Anggraini, A., Lestari, S.R., & Saptasari, M. 2022. Development of problem based learning e-module based on research hormone leptin levels in rats hyperglycemic. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(2):202–217. https://jurnal.usk.ac.id/JPSI/article/view/23399/15534.

Ardhuha, J., Doyan, A., & Susilawati. 2019. Pengembangan modul ajar pada mata kuliah pendahuluan fisika zat padat untuk meningkatkan penguasaan konsep struktur kristal bagi calon guru. *Jurnal Pendidikan Fisika dan Teknologi*, 5(1):40–49. https://jurnalfkip.unram.ac.id/index.php/JPFT/article/view/951/pdf.

Arkhipova, S.V. & Podshivalova, M.S. 2021. Development of psychomotor functions in preschool children with intellectual disabilities through the means of correctional eurhythmics. *Propositos Representaciones*, 9(2):1-13. https://files.eric.ed.gov/ fulltext/EJ1299119.pdf. Doi:10.20511/pyr2021.v9nspe2.984.

Ava, A.T. & Page, A. 2020. Culturally responsive pedagogy for sustainable quality education in the cook islands setting. *Waikato Journal of Education*, 25(1):31–41. https://wje.org.nz/index.php/WJE/article/view/714/663. Doi:10.15663/wje. v25i0.714.

Baehaqi, M.L. & Murdiono, M. 2020. Strengthening discipline character of students at Muhammadiyah Boarding-School (MBS) Muhiba Yogyakarta. *Dinamika Ilmu*, 20(1):63–82. https://files.eric.ed.gov/fulltext/EJ1258122.pdf.

Bare, Y. & Sari, D.R.T. 2021. Pengembangan lembar kerja mahasiswa (LKM) berbasis inkuiri pada materi interaksi molekuler. *Bioeduin*, 11(1):19-26. https://journal.uinsgd.ac.id/index.php/bioeduin/article/view/12077/5369. https://doi.org/10.15575/bioeduin.v11i1.12077.

Demircioglu, T. 2022. The effect of online argumentation in open-ended physics experiments on academic achievement and the change in argumentation abilities. *International Journal of Curriculum and Instruction*, 14(2):1561–1577. https://files.eric.ed.gov/fulltext/EJ1340925.pdf.

Falsarone, A. 2022. *The impact challenge reframing sustainability for businesses*. Washington: Taylor & Francis. https://library.oapen.org/bitstream/handle/20.50012657/53244/9781000562835.pdf?sequence=1.

Fatmaryanti, S.D., Pratiwi, U., Akhdinirwanto, R.W., & Sulisworo, D. 2022. A task model for supporting virtual laboratory based on inquiry skills, social and scientific communication. *International Journal of Evaluation and Research in Education*, 11(1):385–391.https://files.eric.ed.gov/fulltext/EJ1340428.pdf. Doi:10.11591/ijere.v11i1.21737.

Gerard, A., McGrath, A., Colvin, E., & Gainsford, A. 2021. *Children, care and crime: Trauma and transformation*. London: Taylor & Francis. https://www.taylorfrancis.com/books/mono/10.4324/9781003093367/childrencare-crime-emma-colvin-annette-gainsford-alison-gerard-andrew-mcgrath. Doi:10.4324/9781003093367.

Glerum, J., Dimeska, A., Loyens, S.M.M., & Rikers, R.M.J.P. 2020. Does level of education influence the development of adolescents' mindsets. *Education Sciences*, 10(12): 1–8. https://www.mdpi.com/2227-7102/10/12/367.

Hackmann, H. 2022. *Transformative pathways to sustainability: Learning across disciplines, cultures and contexts*. New York: Taylor & Francis. https://library.oapen.org/viewer/web/viewer.html?file=/bitstream/handle/20.500.12657/50519/9781000465105.pdf?sequence=1&isAllowed=y.

Hatchimonji, D.R., Vaid, E., Linsky, A.C.V., Nayman, S.J., Yuan, M., MacDonnell, M., & Elias, M.J. 2022. Exploring relations among social-emotional and character development targets: Character virtue, social-emotional learning skills, and positive purpose. *International Journal of Emotional Education*, 14(1):20–37. https://www.proquest.com/openview/555b3d1a3c6633874c51cdf1db2144ba/1?pq-origsite=gscholar&cbl=2031381. Doi: https://doi.org/10.56300/EVIP7836.

Hermana, P., & Suganda, L.A. 2021. Indonesian pre-service teachers mindfulness, social emotional competence, and academic achievement. *International Journal of Evaluation and Research in Education*, 10(4):1176–1184. https://files.eric.ed.gov/fulltext/EJ1328114.pdf. Doi: 10.11591/IJERE.V10I4.21272.

Hermino, A. & Arifin, I. 2020. Contextual character education for students in the senior high school. *European Journal of Educational Research*, 9(3):1009–1023. https://files.eric.ed.gov/fulltext/EJ1262407.pdf. Doi: 10.12973/EU-JER.9.3.1009.

Hibbert, P. 2021. *Responsible management education research*, *responsible Management Education*. Washington: Taylor & Francis. https://www.taylorfrancis.com/pdf viewer/ Doi:10.4324/9781003186311-32.

Hidayati, N.A., Waluyo, H.J., & Winarni, R. 2020. Exploring the implementation of local wisdom-based character education among indonesian higher education students. *International Journal of Instruction*, 13(2):179–198. https://files.eric.ed.gov/fulltext/EJ1249134.pdf. Doi: 10.29333/iji.2020.13213a.

Husna, A., Hasan, M., Mustafa, M., Syukri, M., & Yusrizal, Y. 2020. Pengembangan modul fisika berbasis integrasi islam-sains pada materi gerak lurus untuk meningkatkan hasil belajar peserta didik. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(1):55–66. https://jurnal.usk.ac.id/JPSI/article/view/15539/11992. Doi:10.24815/jpsi.v8i1.15539.

Jalinus, N., Syahril, & Nabawi, R.A. 2019. A comparison of the problem-solving skills of students in PJBL versus CPJBL model: An experimental study. *Journal of Technical Education and Training*, 11(1):36–43. https://publisher.uthm.edu.my/ojs/index.php/JTET/article/view/3154/2133. Doi:10.30880/jtet.2019.11.01.005.

Jamaluddin, A.B, Zubaidah, S., Mahanal, S., & Gofur, A. 2022. Exploration of the Indonesian Makassar-Buginese Siri' educational values: The foundation of character education. *International Journal of Evaluation and Research in Education*, 11(1):10–19. https://files.eric.ed.gov/fulltext/EJ1341147.pdf. https://doi.org/10.11591/ijere.v11i1.21670

Jorgensen, R.R. 2023. *Loving your job in special education*. New York: Taylor & Francis. Doi: 10.4324/9781003322528.

Karatas, P. & Aktan, E.A. 2022. Relation between creativity, executive functions and bilingualism. *Journal of Language and Linguistic Studies*, 18(1):240–248. https://search.informit.org/doi/abs/10.3316/informit.544673348256020.

Khoiriyah, Z., Astriani, D., & Qosyim, A. 2021. Efektivitas pendekatan etnosains dalam pembelajaran daring untuk meningkatkan motivasi dan hasil belajar siswa materi kalor. *Pensa E-Jurnal : Pendidikan Sains*, 9(3):433–442. https://ejournal.unesa.ac.id/index.php/pensa/article/view/41094/36822.

Komalasari, K. & Saripudin, D. 2018. The influence of living values education-based civic education textbook on student's character formation. *International Journal of Instruction,* 11(1):395–410. https://eric.ed.gov/?id=EJ1165225. https://doi.org/10.12973/iji.2018.11127a

Luszczynska, M. 2021. *Ageing as a social challenge: Individual, family and social aspects in Poland*. Washington: Taylor & Francis. https://books.google.com.my/books?hl=id&lr=&id=J1tQEAAAQBAJ&oi=fnd&pg=PT8&dq=10.4324/b22775&ots=0GM-risiPj&sig=zI2AFwPqkpmPBLRDe9oBCH4v_E#v=onepage&q=10.4324%2Fb22775&f=false. Doi:10.4324/b22775.

Maureen, I., Imah, E., Savira, S. Anam, S., Mael, M., & Hartanti, L. 2022. Innovation on education and social sciences. *Proceedings of the International Joint Conference on Arts and Humanities*. https://library.oapen.org/viewer/web/viewer.html?file=/bitstream/handle/20.500.12657/53232/9781000581607.pdf?sequence=1&isAllowed=y. Doi: 10.1201/9781003265061-26.

Mayer, W. & Wet, C.L.D. 2018. *Reconceiving religious conflict: New views from the formative centuries of Christianity*. New York: Routledge. https://online.ucpress.edu/SLA/article-abstract/3/2/294/67650/Review-Reconceiving-Religious-Conflict-New-Views. Doi:10.4324/9781315387666.

Meier, M.A., Burgstaller, J.A., Benedek, M., Vogel, S.E., & Grabner, R.H. 2021. Mathematical creativity in adults: Its measurement and its relation to intelligence, mathematical competence and general creativity. *Journal of Intelligence*, 9(1):1–27. https://www.mdpi.com/2079-3200/9/1/10. Doi:10.3390/jintelligence9010010.

Montessori, M., Tiara, M., Ambiyar, & Islami, S. 2021. Dialogue method in high school anti-corruption education. *Journal of Social Studies Education Research,* 12(4):1–21. https://files.eric.ed.gov/fulltext/EJ1334393.pdf.

Mustu, O.E. & Sen, A.I. 2019. A comparison of learning high school modern physics topics based on two different curricula. *Science Education International*, 30(4):291–297. https://files.eric.ed.gov/fulltext/EJ1236356.pdf. Doi: 10.33828/sei.v30.i4.6.

Nordin, N.M. & Osman, K. 2018. Students generated animation: An innovative approach to inculcate collaborative problem solving (CPS) skills in learning physics. *Journal of Education in Science, Environment and Health*, 4(2):206-226. https://dergipark.org.tr/en/download/article-file/494155. Doi:10.21891/jeseh.436758.

Ozkan, G. & Umdu, T.U. 2021. Analysis of Turkish science education curricula's learning outcomes according to science process skills. *Mimbar Sekolah Dasar,* 8(3):295–306. https://files.eric.ed.gov/fulltext/EJ1321717.pdf. https://doi.org/10.53400/mimbar-sd.v8i3.35746.

Pamungkas, J., Suyuti, S., Suminto, A., & Rohman, A. 2021. Character value that formed through learning the art of playing GACIL in early childhood. *Cypriot Journal of Educational Sciences,* 16(4):1503–1516. https://files.eric.ed.gov/fulltext/EJ1316515.pdf. https://doi.org/10.18844/cjes.v16i4.6004

Phelps, V. & Lewis, K. 2015. *Strength-based goal setting in gifted education : Addressing social emotional awareness, self-advocacy, and underachievement in gifted education*. New York: Routledge. Doi:10.4324/9781003331049.

Pratama, F., Firman & Neviyarni. 2019. Pengaruh motivasi belajar IPA siswa terhadap hasil belajar. *Edukatif : Jurnal Ilmu Pendidikan*, 1(3):280–286. https://edukatif.org/index.php/edukatif/article/view/63/pdf. https://doi.org/10.31004/edukatif.v1i3.63

Ramdani, A. & Artayasa, I.P. 2020. Keterampilan berpikir kreatif mahasiswa dalam pembelajaran IPA menggunakan model inkuiri terbuka. *Jurnal Pendidikan Sains*

Indonesia (Indonesian Journal of Science Education), 8(1):1–9. https://jurnal.usk.ac.id/JPSI/article/view/15394/11987. Doi: 10.24815/jpsi.v8i1.15394.

Rosa, S., Olivia, I., Gayatri, S., Fitria, T.N., & Rojabi, A.R. 2021. Increasing youth awareness of local culture through active learning. *Cypriot Journal of Educational Sciences,* 16(4):1582-1601 https://files.eric.ed.gov/fulltext/EJ1316458.pdf. https://doi.org/https://doi.org/10.18844/cjes.v16i4.6014

Sadykhan, K., Azizkhoja, K., Gulnar, K., Nurlan, K., Askar, M., & Azimkhuzha, P. 2022. Research of pedagogical conditions for the development of students' educational independence. *Cypriot Journal of Educational Sciences,* 17(5):1838–1851. https://files.eric.ed.gov/fulltext/EJ1349221.pdf. https://doi.org/10.18844/cjes.v17i5.7348

Sanborn, F.W. 2023. *A cognitive psychology of mass communication*. New York: Rotledge. Doi:10.4324/9781003154570.

Sari, I.K.W. & Wulandari, R. 2020. Analisis kemampuan kognitif dalam pembelajaran IPA SMP. *Jurnal Pendidikan dan Pembelajaran Sains Indonesia (Indonesian Journal of Science Education)*, 3(2):145–152. https://ejournal.undiksha.ac.id/index.php/JPPSI/article/view/28559. https://doi.org/10.23887/jppsi.v3i2.28559.

Saudelli, M.G. 2021. Phet simulations in undergraduate physics: Constructivist learning theory in practice. *52 Brock Education Journal*, 31(1):52–69. https://journals.library.brocku.ca/brocked/index.php/home/article/view/899 https://doi.org/10.26522/brocked.v31i1.899.

Scott, J. & Bajaj, M. 2023. *World yearbook of education 2023: Racialization and educational inequality in global perspective*. London: Taylor & Francis. https://www.researchgate.net/profile/Gaurav-Pathania2/publication/370441183_World_Yearbook_of_Education_2023_Racialization_and_educational_inequality_in_global_perspective. Doi:10.4324/9781003241393.

Setiaji, B. & Dinata, P.A.C. 2020. Analisis kesiapan mahasiswa jurusan pendidikan fisika menggunakan e-learning dalam situasi pandemi Covid-19. *Jurnal Inovasi Pendidikan IPA*, 6(1):59–70. https://journal.uny.ac.id/index.php/jipi/article/view/31562/14041. Doi: 10.21831/jipi.v6i1.31562.

Skoglund, J., Holtan, A., & Thornblad, R. 2022. *Childhood in kinship care: A longitudinal investigation*. Washington: Taylor & Francis. https://library.oapen.org/handle/20.500.12657/53421. Doi: 10.4324/9781003231363.

Sopacua, J., Fadli, M.R., & Rochmat, S. 2020. The history learning module integrated character values. *Journal of Education and Learning (EduLearn),* 14(3):463–472. https://files.eric.ed.gov/fulltext/EJ1266479.pdf. https://doi.org/10.11591/edulearn.v14i3.16139.

Stewart, T.J. 2022. *Interdisciplinary research in gender: Sex work on campus*. New York: Taylor & Francis. https://library.oapen.org/handle/20.500.12657/54480. Doi: 10.4324/9781003194101-3.

Sukmak, W. & Musik, P. 2022. Real-time graphing of simple harmonic motion of mass on springs with an arduino based on an experiment set for teaching and learning physics. *Turkish Online Journal of Educational Technology.* 21(1):114–123. https://files.eric.ed.gov/fulltext/EJ1338131.pdf.

Suyitno, H., Zaenuri, Sugiharti, E., Suyitno, A., & Baba, T. 2019. Integration of character valuesin teaching-learning process of mathematics at elementary school of Japan. *International Journal of Instruction,* 12(3):781–794. https://files.eric.ed.gov/fulltext/EJ1220209.pdf. https://doi.org/10.29333/iji.2019.12347a

Teo, T.W., Tan, A.L., & Teng, P. 2022. *Stem education from Asia trends and perspectives.* New York: Taylor & Francis. https://books.google.com.my/books?hl=id&lr=&id=kIlSEAAAQBAJ&oi=fnd&pg=PT12&dq=Stem+education+from+asia+trends+and+perspectives&ots=UpkzD2ouzf&sig=0ibMlGh8Mkge-UwU4zHq1Y-nwsk#v=onepage&q=Stem%20education%20from%20asia%20trends%20and%20perspectives&f=false. Doi:10.4324/9781003099888.

Thalib, M.A. 2022. Pelatihan teknik pengumpulan data dalam metode kualitatif untuk riset akuntansi budaya. *Jurnal Pengabdian pada Masyarakat.* 2(1):44–50. https://seandanan.fisip.unila.ac.id/index.php/seandanan/article/view/29/28. https://doi.org/10.23960/seandanan.v2i1.29.

Vugt, L.V*.* 2022. The role of education systems in preventing NEETs. *The Dynamics of Marginalized Youth*:205–218. Doi:10.4324/9781003096658-8.97810589801.pdf.

Wahjusaputri, S. & Nastiti, T.I. 2022. Digital literacy competency indicator for Indonesian high vocational education needs. *Journal of Education and Learning (EduLearn),* 16(1):85–91. https://files.eric.ed.gov/fulltext/EJ1339628.pdf.

Yilmaz, A. 2021. Evaluation of 2013 preschool curriculum objectives and indicators according to revised bloom's taxonomy. *International Journal of Curriculum and Instructional Studies*. 11(1):1–22. https://files.eric.ed.gov/fulltext/EJ1312494.pdf. Doi:10.31704/ijocis.2021.001.

Zaim, M., Refnaldi, R., & Arsyad, S. 2020. Authentic assessment for speaking skills: Problem and solution for english secondary school teachers in Indonesia. *International Journal of Instruction,* 13(3):587–604. https://files.eric.ed.gov/fulltext/EJ1259521.pdf.

Zulfa, L.N. & Haryanto, H. 2021. Pengaruh media macromedia flash terhadap literasi sains dan sikap demokratis mahasiswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(1):52–64. https://jurnal.usk.ac.id/JPSI/article/view/18266/13310.

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Profile of Critical Thinking Skills of Chemistry Education Students in Solving Problems Related to the Concept of Mole

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Abstract. Critical thinking skills are needed in solving problems because identitying problems requires an analytical thinking process based on clear data and reasons. The purpose of this study was to describe the critical thinking skills of chemistry education students class of 2020 in solving problems related to the mole concept. The type of research used in this study is descriptive quantitative. Subjects who participated voluntarily in this study were 38 people out of 49 chemistry education students class of 2020. Data collection techniques using measurement and direct communication. The research instrument used was adopted from the stoichiometry e-book developed by Rahmat Rasmawan in 2022 which has been validated by 10 validators with a score of 85 which means it is valid and can be used. The data analysis technique used was descriptive analysis. The results showed that critical thinking skills in the skilled category was 40%, while in the less and unskilled were 55% and 5% respectively. In each indicator, which are making assumptions is in the highly skilled criteria with 66%, making inductive thinking conclusions are in the skilled criteria with 84%, and interpreting information is in the unskilled criteria with 61%. The critical thinking skills of students in the 2020 chemistry education class are still in the unskilled category, this is due to the inhibiting factors, namely the online learning system and inappropriate learning methods.
Keywords: Critical Thinking, Problem-Solving, Quantitative, Problem-Based Learning, Online Learning

Introduction

The 21st century is a period full of challenges where the development of the industrial revolution is growing very rapidly. Global changes in various aspects of life and rapid world development are challenges for the nation in preparing future generations (Rachmantika & Wardono, 2019). One of the developments that occurred in the 21st century was the improvement of science and technology (IPTEK). Developments that occur in science and technology result in an increase in the field of science. One of the difficuties in development in the 21st century is the challenge of solving problems.

These challenges are also in line with the kerangka kualifikasi nasional ndonesia which states that undergraduate graduates must be able to adapt to current conditions and use science, technology, or art in the field of problem-solving. Then graduates must be able to formulate procedural solutions to problems and understand general theoretical concepts and specific theoretical concepts from various scientific fields. In addition, they can able to assist individuals and groups in choosing alternative solutions and making appropriate decisions based on information and data analysis. From these expectations and challenges, a person, especially a student, must be able to solve future problems and be able to provide solutions from the results of the data analysis carried out. To help face the challenges in solving these problems, skills are needed that can solve these difficulties.

Critical thinking skills are one of the things that help in problem-solving. Álvarez-Huerta et al. (2022) argued that critical thinking is an important complement to cognitive processes to deal with complex problems. Matthee & Turpin (2019) argued that a person needs an analytical mindset based on critical thinking to solve a problem. One must be a critical thinker in addressing various problems. Critical thinking allows a person to make decisions and take action more quickly by organizing, adjusting, reconstructing, or improving their thinking (Maulana, 2017). A person goes through a rational process before finding a reasonable solution. The rational critical thinking process aims to decide whether to believe or do something. Therefore, critical thinking skills need to be developed to help solve problems that come later.

Critical thinking skills require higher-order cognitive processes (Barta et al., 2022). To achieve critical thinking skills, it is developed through the educational process. In the 21st century, critical thinking has long been an important terminology in the educational process and has a very specific definition (Belecina & Ocampo, 2018). The educational process is one of the mainstays to improving critical thinking skills. Critical thinking is a core academic skill that teaches students to question or reflect on their knowledge of the information presented (Seki et al., 2022). Wiliawanto et al. (2019) suggested that critical thinking is the most important part of learning objectives. The Chemistry Education Study Program of FKIP Tanjungpura University is one of the universities in pontianak that aims to prepare prospective chemistry teachers at the junior and senior high school levels. Students in the chemistry education study program must be able to meet the graduate learning outcomes, one of which is that students can use logical, systematic, critical, and innovative thinking in the context of improving or applying science and/or technology based on their field of expertise. Then students must be able to apply this way of thinking to solve problems in their field by determining the right decision based on the results of information and data analysis. Therefore, critical thinking skills need to be improved in the learning process.

Mole concept material is one of the materials contained in chemistry learning. The material of the mole concept is the relationship between moles, molar mass, and molar volume. In this study, the mole concept material is used as the basis for measuring critical thinking skills in solving problems related to the mole concept. This is because the mole concept material is often considered easy by students because the mole concept material that students know is only calculating the mole content in a compound. But in reality, when the concept of a mole is associated with a form of problem-solving in everyday life, it is found that there are still many students who fail to solve it.

The basis for choosing the mole concept material is also supported by the results of an interview with one of the students. According to the results of the interview, students understand the concept of a mole and how to calculate the mole content in a compound. But when the concept of a mole is implemented in the form of problems in everyday life, it is found that many students fail to solve the mole concept problem. This is because the concept of moles is often considered easy by students because what students know is only to calculate the mole content of a compound in the material.

Some research results show that students' critical thinking skills need attention. Among them is research conducted by Oktariani et al. (2020) which analyzes the critical thinking skills of prospective chemistry teachers at the Islamic University of Riau and shows that the ability of chemistry education students is still at sufficient criteria, especially on indicators of providing explanations or making assumptions, building conclusions, and developing strategies or solutions. Then supported by research by Suryani et al. (2020) which suggests that students' critical thinking skills are still at low criteria, and the indicators used are also the same as previous research, namely providing explanations or making assumptions, building conclusions, and developing strategies or solutions. However, of the many studies that analyze students' critical thinking skills, there is still no one who analyzes students' critical thinking skills in solving problems related to the concept of moles. Therefore, researchers are interested in analyzing how the critical thinking skills of chemistry education students of FKIP UNTAN class of 2020 in solving problems related to the concept of mole. To measure this, a tool is used to measure critical thinking skills. as for the tool to measure critical thinking skills is a problem solving problem adopted from the stoichiometry e-book developed by Rahmat Rasmawan in 2022 which has been validated. The purpose of using this tool is to determine the extent of students' ability to think critically when faced with a problem.

Methods

This research uses a descriptive method with a quantitative approach. The subjects of this study were chemistry education students class of 2020 consisting of 2 classes and totaling 38 people out of a total of 49 people who participated voluntarily. This research subject was taken because it was considered to have received material related to the concept of mole and already had some skills in critical thinking if faced with a problem. The data collection technique used is a measurement technique, namely by giving a test of problem-solving questions adopted from the stoichiometry e-book developed by Rasmawan (2022) and has been validated by 10 validators with a score of 85. The questions adopted have been adapted to critical thinking indicators. The relationship between problem indicators and critical thinking indicators can be seen in Table 1.

Table 1. The relationship between Critical Thinking Indicators and Problem Indicators

No	Critical Thinking Indicators	Problem Indicators
1	Making Assumptions	Students can predict the storage volume capacity needed to accommodate CO_2 with different temperatures and pressures.
2	Making Inductive Thinking Conclusions	Students can conclude the minimum mass of succimer needed to bind lead in the blood of poisoned patients.
3	Interpreting Information	Students can suggest the volume of seawater needed for a solution to pay off the compensation suffered by Jerman in World War 1.

The data analysis is done by scoring the answers using a scoring rubric that has been adjusted to the critical thinking indicators. The critical thinking indicators used are adopted from Rasmawan (2017) which consist of making assumptions, making inductive thinking conclusions, and interpreting information. After obtaining the overall score, the average score is calculated to determine the criteria of critical thinking skills by totaling the scores and then taking the average. Then the results of the average scoring are grouped into the critical thinking skills category.

Table 2. Category for Critical Thinking Skills

Score	Category
≥ 3.50	Highly skilled
2.50 – 3.49	Skilled
1.50 – 2.49	Less skilled
0.00 – 1.49	Unskilled

After grouping into categories, interviews were conducted with 10 students who were taken based on the high, skilled, less, and unskilled categories seen from the answers given by students and the results of data analysis. Then the results of the analysis and interview results are described using a quantitative approach.

Result and Discussion

The results of critical thinking skills of chemistry education students class of 2020 are in the skilled category with a percentage of 40%, the less skilled category has a percentage of 55% and the unskilled category has a percentage of 5%. The results are presented in Figure 1.

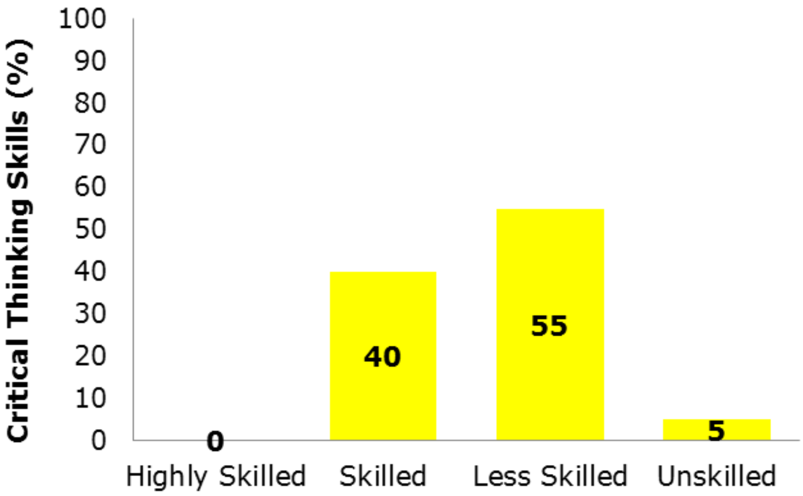


Figure 1. Results of Students' Critical Thinking Skills

Figure 1 shows the results of the critical thinking skills of the chemistry education students class of 2020 as a whole. Based on the results of critical thinking skills, it is found that the average of students are still in the low category. This is by the results of interviews which state that students are not familiar with the concept of moles that are implemented in problems in everyday life. Someone will use their critical thinking if faced with problem-solving. Therefore, critical thinking skills are needed in solving problems that will be faced. The results of this study are also in line with the results of research by Rasmawan (2017) which suggests that the critical thinking skills of chemistry education students are still relatively low, namely in the less skilled category.

The results of critical thinking skills are obtained from the results of tests that have been carried out by giving question sheets to students directly in the joint lecture building B. Students are given 90 minutes to work on the questions that have been given. The questions used in measuring critical thinking skills are in the form of essay questions, namely problem-solving questions with each item adjusted to the indicators measured. Problem number 1 is a problem used to measure indicators of making assumptions. Problem number 2 is used to measure indicators of making inductive thinking conclusions and number 3 is a problem used to measure the interpreting information. The skills of chemistry education students class of 2020 in solving problems related to the concept of moles on each indicator are presented in form Table 3.

Table 3. Percentage of Students' Critical Thinking Skills in Each Indicator

No	Indicator	Highly Skilled	Skilled	Less Skilled	Unskilled
1	Making Assumptions	66	31	3	-
2	Making Inductive Thinking Conclusions	-	84	13	3
3	Interpretation of Information	-	-	39	61

Table 3 shows that the skills of each indicator have different percentages. For the highly skilled category which has the largest percentage is the indicator of making assumptions at 66%, while for the skilled category, the largest percentage is in the indicator of making inductive thinking conclusions at 84%. The less skilled category which has the largest percentage is the indicator interpreting information of 39% and the unskilled category of the indicator interpreting information has the largest percentage of 61%.

From the results of student answers, it can be seen the level of the questions given. The level of the questions given can be seen from the results of the average score of student answers presented in Figure 2.

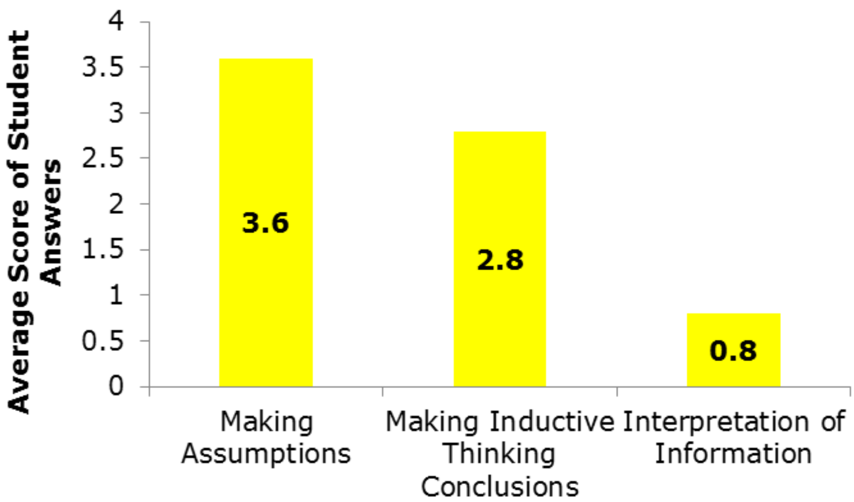


Figure 2. Average Score of Student Answers.

From Figure 2, it can be seen that questions with indicators of making assumptions are the easiest level questions, this is because the results of the average score show a high number of 3.6 with a very skilled category. Then questions with indicators of making inductive thinking conclusions are included in questions with a medium level, namely with a score of 2.8 in the skillful category. However, on questions with interpreting information indicators, the score obtained is only 0,8 in the unskilled category. This indicates that the level of the problem with the information interpretation indicator is the most complicated problem to solve.

Making Assumptions

In the indicator of making assumptions, students are asked to be able to make assumptions based on consideration of factual background factors and provide clear and logical justification. This indicator measures how students' skills in providing assumptions based on background and clear justification when faced with problem-solving. The percentage results of the indicator of making assumptions are presented in Figure 3.

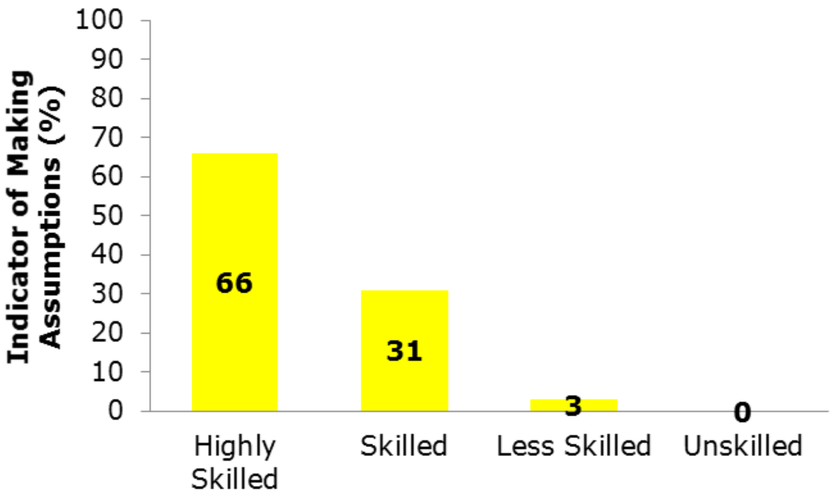
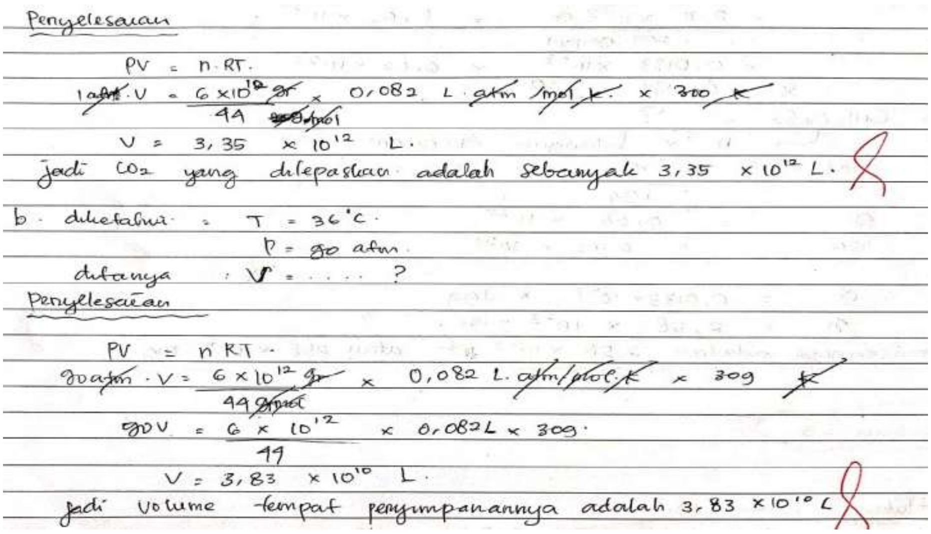


Figure 3. Percentage Results of Making Assumptions

Figure 3 shows that in the highly skilled category, 66% of students answered the question with the calculation results showing the storage and release volumes based on clear facts about the background and acceptable justifications. The background and justification given in students' answers are in the question asked about the volume of CO_2 with different temperatures and pressures, students provide justification with the assumption that CO_2 is an ideal gas. This is in line with the theory which suggests that CO_2 can include ideal gas with acceptable differences. Therefore, to calculate the volume in question, the calculation process uses the ideal gas formula, namely $PV = nRT$ with R as the ideal gas constant. Student answers in the highly skilled category can be seen in Figure 4.



Penyelesaian

$PV = n.RT.$

$1\,atm.V = \frac{6 \times 10^{12}\,gr}{44\,gr/mol} \times 0,082\ L.atm/mol.K \times 300\ K$

$V = 3,35 \times 10^{12}\ L.$

Jadi CO_2 yang dilepaskan adalah sebanyak $3,35 \times 10^{12}$ L.

b. diketahui : $T = 36\,^{\circ}C.$

$P = 90$ atm.

ditanya : $V = \ldots$?

Penyelesaian

$PV = n\,RT$

$90\,atm.V = \frac{6 \times 10^{12}\,gr}{44\,gr/mol} \times 0,082\ L.atm/mol.K \times 309\ K$

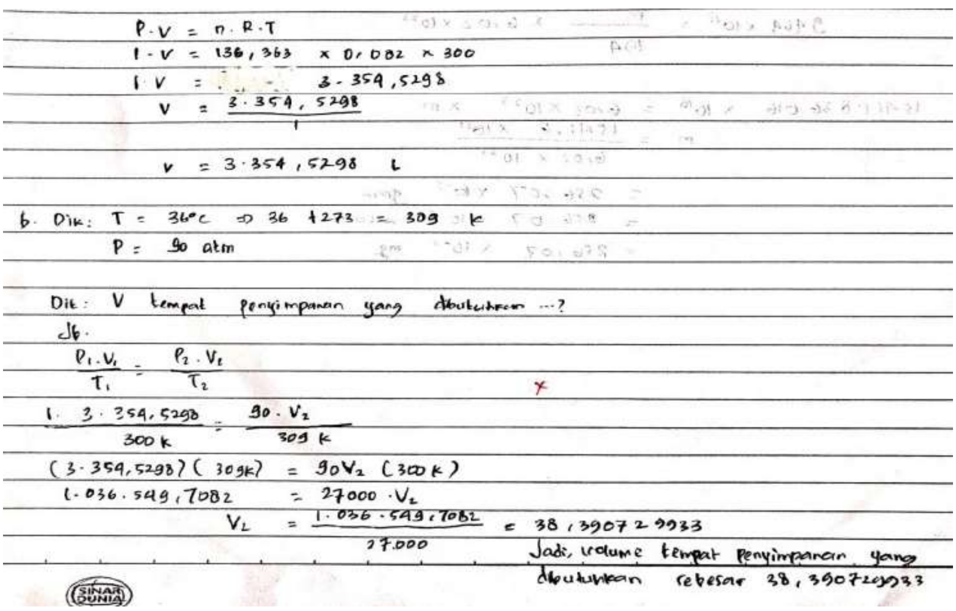
$90V = \frac{6 \times 10^{12}}{44} \times 0,082L \times 309.$

$V = 3,83 \times 10^{10}\ L.$

Jadi volume tempat penyimpanannya adalah $3,83 \times 10^{10}$ L

Figure 4. Student Answers in the Highly Skilled Category

Then for the skillful category, the student's answer is 31% with the answer that the calculation results show the storage and release volume based on a clear factual background but the justification for the calculation results is not clear. The answers of students in the skillful category can be seen in Figure 5.



$P.V = n.R.T$

$1.V = 136,363 \times 0,082 \times 300$

$1.V = 3.354,5298$

$V = \frac{3.354,5298}{1}$

$V = 3.354,5298$ L

b. Dik: $T = 36\,^{\circ}C \Rightarrow 36 + 273 = 309$ K

$P = 90$ atm

Dit: V tempat penyimpanan yang dibutuhkan ...?

Jb.

$\frac{P_1.V_1}{T_1} = \frac{P_2.V_2}{T_2}$

$\frac{1.\ 3.354,5298}{300\ K} = \frac{90.V_2}{309\ K}$

$(3.354,5298)(309K) = 90V_2\ (300K)$

$1.036.549,7082 = 27000.V_2$

$V_2 = \frac{1.036.549,7082}{27.000} = 38,3907209933$

Jadi, volume tempat penyimpanan yang dibutuhkan sebesar 38,3907209933

Figure 5. Student Answers in the Skilled Category

In Figure 5, it can be seen that students justify that the volume of release and storage has a relationship and they use the Boyle-Gay Lussac law. Whereas in the question there is no relationship between the volume of release and the volume of storage associated with Boyle-Gay Lussac's law. This is in line with the research of

Romadona et al. (2020) which suggests that there are misconceptions between the application of the use of ideal gas calculations and the calculation of Boyle-Gay Lussac's law.

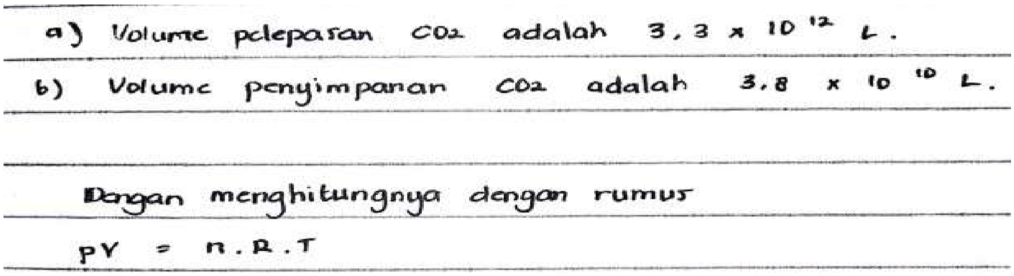


Figure 6. Student Answers in the Less Skilled Category

In Figure 6 are the answers of students in the less skilled category with a percentage of 3% with answers to calculation results based on general factual background and do not justify. Students' answers in the less skilled category only provide the required volume of answers without justifying what they answer.

Making Inductive Thinking Conclusions

In the indicator of making inductive thinking conclusions, students are expected to be able to induce existing data to provide relevant knowledge. Because in making reasonable and rational conclusions, relevant information is needed related to the problem at hand (Sundari & Sarkity, 2021). Students are also expected to be able to connect conclusions and data to obtain clear and logical information. Rijal & Sere (2017) revealed that inductive thinking is drawing conclusions from specific statements to general statements. Therefore, this indicator measures how students' skills make conclusions by linking data clearly in solving a problem. The percentage results of the inductive thinkingconclusion indicator are presented in Figure 7.

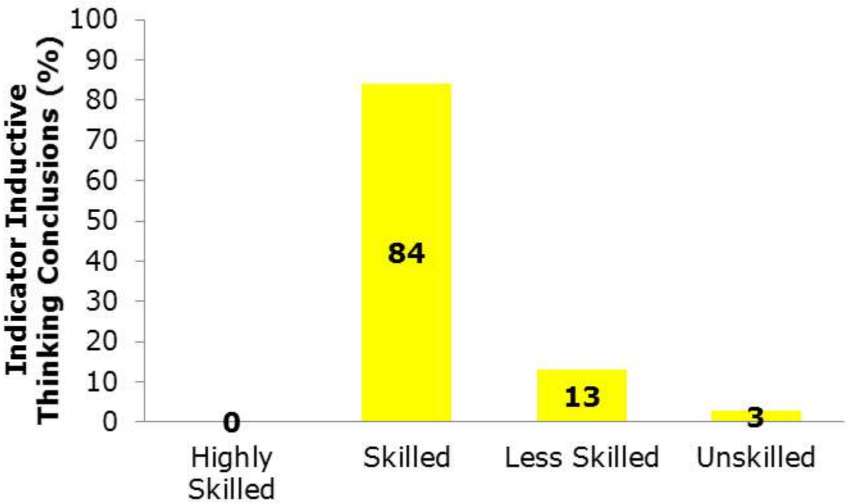


Figure 7. Percentage Results of Making Inductive Thinking Conclusions

Figure 7 shows that in the skillful category of 84% where students perform induction by using relevant information, data, or knowledge but the relationship is still not clear so that it can cause bias. In this category, the students answers can be seen in Figure 8.

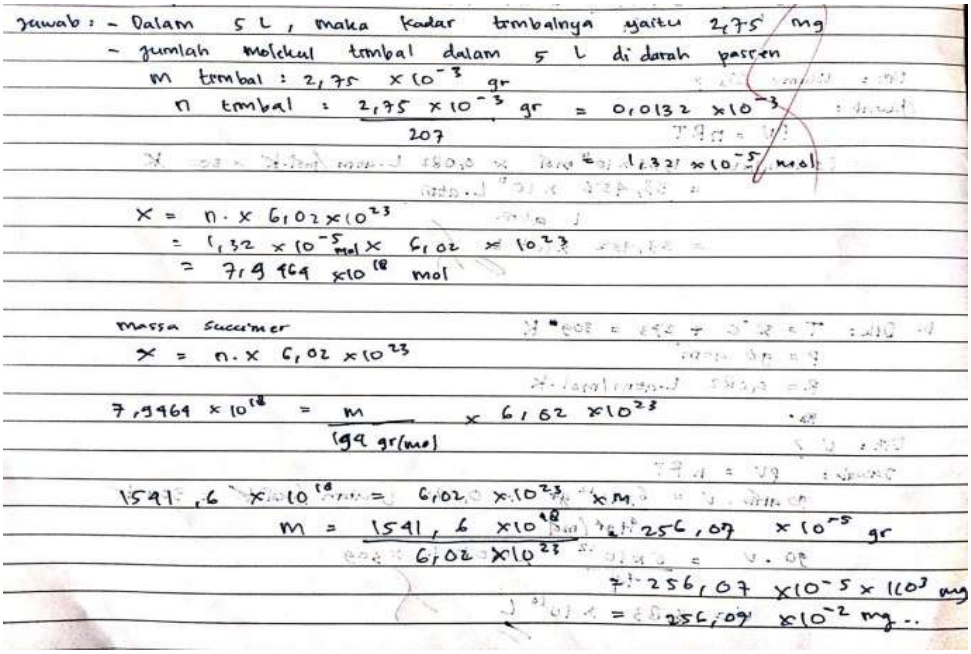

Jawab : - Dalam 5 L, maka kadar timbalnya yaitu 2,75 mg
- jumlah molekul timbal dalam 5 L di darah pasien
m timbal : 2,75 × 10^-3 gr
n timbal : 2,75 × 10^-3 gr / 207 = 0,0132 × 10^-3
= 1,321 × 10^-5 mol
X = n × 6,02 × 10^23
= 1,32 × 10^-5 mol × 6,02 × 10^23
= 7,9464 × 10^18 mol
massa succimer
X = n × 6,02 × 10^23
7,9464 × 10^18 = m / 199 gr/mol × 6,02 × 10^23
1591,6 × 10^18 = 6,02 × 10^23 × m
m = 1591,6 × 10^18 / 6,02 × 10^23 = 256,07 × 10^-5 gr
= 256,07 × 10^-5 × 10^3 mg
= 256,07 × 10^-2 mg..

Figure 8. Student Answer in the Skilled Category

In Figure 8, the student answers by inducing data from calculating the total mass of lead in the blood then finding moles of lead and then connecting moles of lead with moles of succimer. However, in the calculation the student related it to the number of particles instead of relating it to the mass of succimer needed to bind the lead. The calculation does not need to be associated with the number of particles, therefore the results cause irrelevant.

Then the category of less skillful students' answers amounted to 13% where the student only do induction but the data used is not related to the conclusions formulated. In this category, students' answers can be seen in Figure 9.

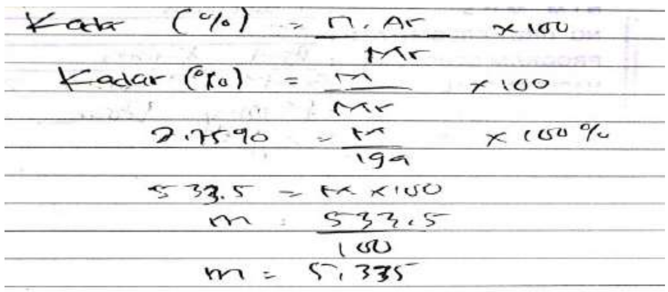

Kadar (%) = n . Ar / Mr × 100
Kadar (%) = m / Mr × 100
2,7590 = m / 199 × 100 %
533,5 = m × 100
m = 533,5 / 100
m = 5,335

Figure 9. Student Answer in the Less Skilled Category

In Figure 9, students answered by inducing data from moles of lead which is related to the percent lead content. The data used in this answer has no relationship with the conclusion formulated because to find the minimum mass of the succimer there is no need to find the percent lead content.

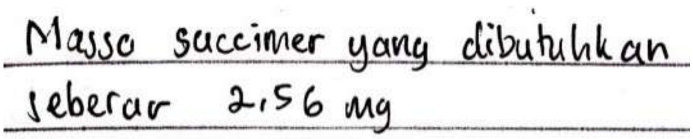


Figure 10. Student Answer in the Unskilled Category

Figure 10 is an unskilled student answer with a percentage of 3% where students do induction without being supported by the underlying reasons, namely writing directly the mole mass of succimer without any completion process.

Interpreting Information

The information interpretation indicator is used to measure students' ability to interpret information. Interpretation skills are skills to be able to express and understand the significant meaning or meaning of a problem (Solikhin & Fauziah, 2021). Therefore, in this indicator, students are asked to be able to interpret information with the assessment criteria, namely utilizing the measurement results obtained to provide clear information and their relationship with a number so that the proof can be rejected or accepted. The percentage results of the information interpretation indicator are presented in Figure 11.

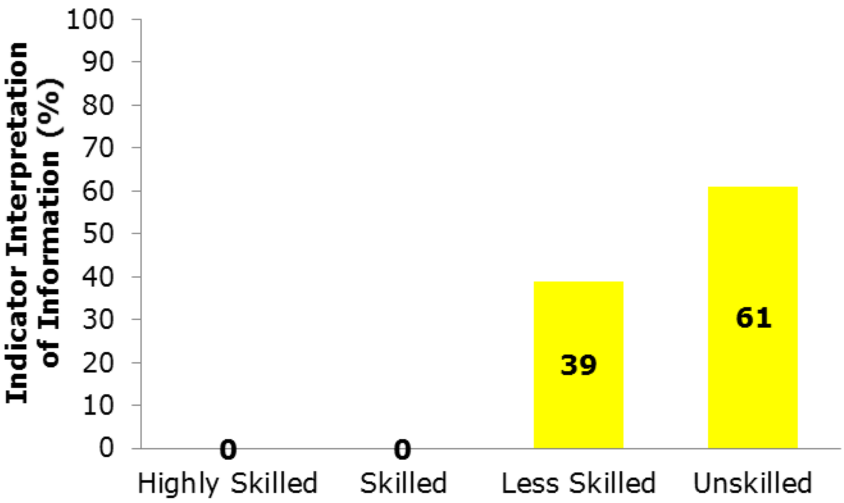


Figure 11. Interpretation of Information Percentage Results

Figure 11 shows that in the highly skilled and skilled categories, none of the students were able to interpreting information by using relevant information, data, or knowledge and could link conclusions logically. Whereas in the less skillfed category, 39% of student answers were where students interpreted information but used information, data, or knowledge that had nothing to do with the conclusions formulated. In the less skilled category, students' answers can be seen in Figure 12.

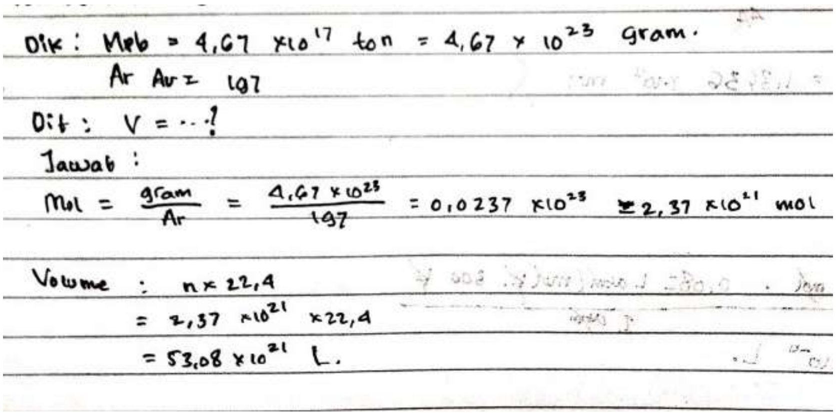


Figure 12. Student Answer in the Less Skilled Category

In Figure 12, students answer by interpreting the information data but the interpretation does not have a relationship to the conclusion asked, namely only calculating the moles of gold and then connecting to the wrong volume formula in finding the required conclusion volume.

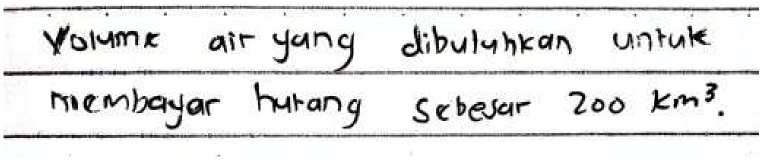


Figure 13. Student Answer in the Unskilled Category

Then in Figure 13 is the answer of student's in the unskilled category with a percentage of 61% where students interpret information but without being accompanied by the underlying reasons.

From the results of the data analysis, it can be seen that the average student's skills are still in the less skilled category. These skills are caused by several obstacles experienced by students mentioned in the results of interviews, they mentioned that in learning students are constrained by the online learning system. This is in line with the opinion of Handayani & Jumadi (2021) who states that students have difficulty understanding the material in online learning. Then students also do not ask the teacher directly if there is a material that cannot be understood. Whereas according to Mukarramah et al. (2021) suggest that the opportunity given by the teacher to ask questions during learning can help improve students' thinking skills. By asking questions, students can criticize various problems that occur around their environment. In addition, in online learning, students also only listen to lecturers without taking notes on what the lecturer discusses. Even though recording material during learning is a way to help students remember the material discussed for a longer time than just listening. This can affect critical thinking skills because if students are not based on the knowledge they get, they will not be able to criticize the problems that will be given related to the material. Then in online learning, students are also constrained by several factors that cause ineffective learning, one of which is difficult internet access. Internet connection is the main component of online learning (Hamdani & Priatna, 2020). Students and lecturers will not be able to interact directly without an internet connection. Syah (2020) argues that an uneven internet network can complicate online learning.

Then not only online learning is an obstacle, but learning methods are also one of the drivers and determinants in the development of critical thinking skills. The success oflearning methods is very influential in learning outcomes. From the results of interviews, students experience problems with learning methods. The learning method used is the lecture method, namely the lecturer explains and students only listen to the explanation of the lecturer. Then sometimes in the learning process, the lecturer only provides material without any further explanation related to the material that has been given. This makes students feel bored with the learning process because the learning methods used do not hone critical thinking skills. This is supported by the opinion of Suwarno (2015) which states that mostly in learning, the teacher acts as the center of information while students just sit and listen to the material given by the teacher. This learning method is difficult to develop students' thinking skills because they only sit and listen without any activities that stimulate their higher-order thinking. One method that can be used to assist in the development of critical thinking skills in solving problems is the problem-based learning (PBL) method. PBL is a learning method that requires students to solve a problem to gain knowledge in learning the learning material (Pratiwiningrum et al., 2022). Putri et al. (2016) argued that the PBL learning method gives students freedom in determining the solution to the problem at hand so that a variety of new answers and opinions are produced by students. Similarly, Syaribuddin et al. (2016) argued that in the PBL learning method, students identify problems given by the teacher, and organize strategies for solving problems to find solutions and conclusions. From the learning process that has been carried out, students can improve their critical thinking skills. In addition to PBL-based learning methods, methods that can help improve critical thinking skills are PBL-STEAM learning methods. Putri et al. (2020) suggested that the learning process with the PBL-STEM method has the potential to spur students' critical thinking skills and motivate them to learn the material. Learning using the STEM-PBL method can develop students' critical thinking skills (Adiwiguna et al., 2019). Fadhilah et al. (2022) suggested that the use of the STEM-PBL method had a good impact on students' critical thinking skills. Febrianto et al. (2021) also mentioned that applying the STEAM-PBL method in learning can develop critical thinking skills in solving problems. Therefore, PBL and PBL-STEAM learning methods can help improve students' critical thinking skills.

Conclusion

From the research conducted, it was concluded that the critical thinking skills of chemistry education students class of 2020 in solving problems related to the concept of moles were still in the less skilled category with a percentage of 55%. This is because students are still not familiar with problems in the form of problem solving so that their critical thinking skills are still low. The supporting factors that hinder students' critical thinking skills are the online learning system and inappropriate learning methods.

References

Adiwiguna, P.S., Dantes, N., & Gunamantha, I.M. 2019. The effect of stem-oriented problem-based learning (PBL) model on critical thinking ability and science literacy of grade V students in Gugus I Gusti Ketut Pudja. *Jurnal Pendidikan Dasar Indonesia*, 3(2):94–103. https://doi.org/10.23887/jpdi.v3i2.2871

Álvarez, H.P., Muela, A., & Larrea, I. 2022. Disposition toward critical thinking and creative confidence beliefs in higher education students: The mediating role of openness to diversity and challenge. *Thinking Skills and Creativity*, 43(1):1-9. https://doi.org/10.1016/j.tsc.2022.101003

Barta, A., Fodor, L.A., Tamas, B., & Szamoskozi, I. 2022. The development of students critical thinking abilities and dispositions through the concept mapping learning method – a meta-analysis. *Educational Research Review*, 37(1):1-17. https://doi.org/10.1016/j.edurev.2022.100481

Belecina, R.R. & Ocampo, Jr.J.M. 2018. Effecting change on students critical thinking in problem-solving. *Educare*, 10(2):109–118. https://doi.org/10.2121/edui-jes.v10i2.949

Fadhilah, N., Nurdiyanti, N., Anisa, A., & Wajdi, M. 2022. Integration of STEAM-problem based learning through online to critical thinking skills of biology education students. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 6(1):1–10. https://doi.org/10.24815/jipi.v6i1.22721

Febrianto, T., Ngabekti, S., & Saptono, S. 2021. The effectiveness of schoology-assisted PBL-STEM to improve critical thinking ability of junior high school students. *Journal of Innovative Science Education*, 10(2):222–229. https://doi.org/10.15294/jise.v9i3.42993

Handayani, N.A. & Jumadi, J. 2021. Analysis of online science learning during the covid-19 pandemic. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(2):217–233. https://doi.org/10.24815/jpsi.v9i2.19033

Matthee, M. & Turpin, M. 2019. Invited paper teaching critical thinking, problem-solving , and design thinking : Preparing IS students for the future. *Information Systems Education,* 30(4):242-252. http://jise.org/Volume30/n4/JISEv30n4 p242.htm

Mukarramah, M., Gani, A., & Winarni, S. 2021. Analysis of the suitability of learning implementation tools with 21st century learning demands. *JIPI (Jurnal IPA & Pembelajaran Ilmu Pengetahuan Alam)*, 5(3):233–241. https://doi.org/10.24815/jipi.v5i3.21934

Oktariani, O., Febliza, A., & Fauziah, N. 2020. Critical thinking skills of chemistry teacher candidates as readiness to face the industrial revolution 4.0. *Journal of Natural Science and Integration*, 3(2):114-127. https://doi.org/10.24014/jnsi. v3i2.8791

Pratiwiningrum, F.M., Hairida, H., Sartika, R.P., & Rasmawan, R. 2022. Description of teachers' ability in designing active learning activities with discovery learning and problem-based learning models. *Edukatif : Jurnal Ilmu Pendidikan*, 4(6):8096–8105. https://doi.org/10.31004/edukatif.v4i6.3675

Putri, C.D., Pursitasari, I.D., & Rubini, B. 2020. Problem-based learning integrated with STEM in the era of the covid-19 pandemic to improve students' critical thinking skills. *JIPI (Jurnal IPA & Pembelajaran IPA*), 4(2):193–204. https://doi.org/10.24815/jipi.v4i2. 17859

Putri, R., Ismail, S., & Hasan, M. 2016. The effect of problem-based learning model on critical thinking and elasticity learning outcomes of Xi class students of Sma Negeri 7 Banda Aceh. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 4(1):117-128. https://jurnal.usk.ac.id/JPSI/article/download/6589/10444

Rachmantika, A.R., & Wardono. 2019. The role of students' critical thinking skills in learning mathematics with problem-solving. *Prosiding Seminar Nasional Matematika*, 2(1):439-443. https://journal.unnes.ac.id/sju/index.php/prisma/

Rasmawan, R. 2017. Profile of critical thinking skills of students and its correlation with academic achievement index. *EduChemia (Jurnal Kimia Dan Pendidikan)*, 2(2):130-140. https://doi.org/10.30870/educhemia.v2i2.1101

Rasmawan, R. 2022. Stoichiometry e-book based on creative problem solving to solve conceptual problems. *Jurnal Pendidikan Kimia Indonesia*, 6(1):70–78. https://doi.org/10.23887/jpk.v6i1.43441

Rijal, M. & Sere, I. 2017. Means of scientific thinking. *Jurnal Biology Science & Education,* 6(2):176-185. http://dx.doi.org/10.33477/bs.v6i2.170

Romadona, N.S., Aulia, W.S.N., Lestari, S.R., & Nana. 2020. Misconception identification using the certainty response index method on gas kinetic theory material in class XI SMA. *Jurnal Pendidikan Fisika*, 8(1):64–70. http://dx.doi.org/10.31258/jgs.8.1.64-70

Seki, N., Sireerat, K., Foxton, R., Liao, S.R., & Morio, I. 2022. Critical thinking education for dental schools in Asia: Perceptions of educators. *Journal of Dental Sciences*, 18(1):443-447. https://doi.org/10.1016/j.jds.2022.08.024

Solikhin, M. & Fauziah, A.N.M. 2021. Analysis of junior high school students' critical thinking skills in science lessons during online learning during the covid-19 pandemic. *Pensa E-Jurnal: Pendidikan Sains,* 9(2):89-93 https://ejournal.unesa.ac.id/index.php/pensa/article/view/38060

Sundari, P.D. & Sarkity, D. 2021. Critical thinking skills of high school students on temperature and heat materials in learning physics. *Journal of Natural Science and Integration,* 4(2):149-161. https://www.researchgate.net/profile/Siti-Harizan/publication/360471070

Suryani, K., Sukardi, S., Khairudin, K., Sasmita, D., & Rahmadani, A.F. 2020. Profile of computer science students on critical and creative thinking skills. *Edukasi: Jurnal Pendidikan*, 18(2):159-169. https://doi.org/10.31571/edukasi.v18i2.1939

Syaribuddin, S., Khaldun, I., & Musri, M. 2016. Application of problem-based learning model with audio visual media on chemical bonding material on concept mastery and critical thinking of students of SMA Negeri 1 Panga. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 4(2):96–105. https://jurnal.usk.ac.id/JPSI/article/view/7585/6235

Wiliawanto, W., Bernard, M., Akbar, P., & Sugandi, A. I. 2019. Penactment of question students has active learning strategy to improve mathematics critical thinking ability of vocational students. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, 3(1):139–148. https://doi.org/10.31004/cendekia.v3i1.86

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Development of Animation Video Learning Media Loaded Contextual on Reaction Material Redox using Web Apps Animaker

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Abstract. Redox materials contain many abstract concepts. Therefore, an animated video is needed to illustrate abstract material to make it more concrete and easier to understand. This study aims to develop animated videos with contextual content on redox reaction materials using Web Apps Animaker and know the product's quality. The data collection procedure was carried out based on the 4 steps of 4D development model (define, design, develop, and disseminate). Data collection techniques used are interview, questionnaires, and product assessment. Product assessment is carried out by material experts, media experts, reviewers, and student responses. The data obtained were analyzed using qualitative and quantitative approaches. The results of product quality assessment by material experts got 92% in the very good category, media experts got 90% in the very good category, and reviewers got 95% in the very good category. Class X high school students responded positively to the product developed with a percentage of 94.5%. Based on the results of the assessment, the videos developed can be used as alternative media for student learning independently or in groups. The developed media can also help teachers to create more innovative learning.
Keywords: animation video, contextual, redox, Animaker

Introduction

Technological developments in the era of the industrial revolution 4.0 influenced the education paradigm in Indonesia. Technology is an essential tool needed in the educational process to achieve learning goals (Firmadani, 2020). The use of technology can maximize the learning process to be more effective and efficient (Apriansyah, 2020). Using technology in the learning process can position the teacher as a facilitator and focus learning activities on students (Myori et al., 2019). Technology can also create a more effective learning process for information cycles (Daulay et al., 2020). In addition, the learning atmosphere can become more conducive and systematic with the use of technology (Salsabilla et al., 2021). But behind the myriad of benefits, the fact is that the use of technology by teachers in the learning process is still in the low category and has not been used optimally (Setiawan et al., 2019).

The lack of teacher skills and knowledge about technology causes minimal application of digitalization in the learning process (Wen & Tan, 2020). Technology-based learning media development training can be a solution for improving teacher skills in technology (Kis et al., 2021). These training activities can provide new insights for teachers regarding the development of technology-based learning media and their benefits in the learning process (Sari et al., 2020). Learning media is a supporting tool that can make delivering and receiving material in class more interactive (Nurrita, 2018). Accuracy in determining learning media can strengthen material delivery to be more concrete and increase student learning motivation (Rasagama, 2020). However, when observing phenomena in schools, teachers are generally still dominant in using instructional media in the form of textbooks and modules (Effendi et al., 2020). Print media, such as textbooks, and modules, tend to be informative, reducing students' interest in participating in learning. Based on the survey results, information was obtained that 93.8% of students wanted a renewal of learning media following the times (Muhammad et al., 2020).

Interactive multimedia technology, such as animation videos, can be one of the innovations for teachers in updating learning media. Animated videos are a medium that is composed of audio and visual aspects to convey material (Apriansyah, 2020), providing a comfortable learning atmosphere, increase student learning motivation, and increase student understanding (Bulkani et al., 2022). Visual projections in animation videos are composed of various images that start still and move to resemble a character according to the creator's design. The development of animated videos can be done quickly with the help of web apps Animaker. Web apps Animaker provides a variety of animated characters and features that can combine all characters with sound accompanied by transition effects to create artistic learning videos (Munawar et al., 2020). Animaker has several advantages, such as products that can be downloaded easily, are free of charge, user-friendly, and there are various choices of quality and sizes of the videos provided. The animation features available in Animaker are arranged simply so beginners can learn them quickly. However, most school teachers still have difficulties making animated video-based appropriate learning media to students' characteristics and ways of learning (Sunami & Peace, 2021).

Making learning media appropriate to the type and way of student learning can be realized using a learning approach. The learning approach is a combination of methods and strategies used by the teacher during the learning process (Toraman et al., 2020). Using a learning approach can involve students actively in building their understanding (Dewi & Dwikoranto, 2021). One learning approach suitable for student development is contextual (Angjelina & Asrizal, 2019). Contextual learning can be realized by associating the material studied with its application in everyday life. A contextual approach can make it easier for students to find, understand, and apply the concepts taught by the teacher (Anggraeni et al., 2020). In addition, students can also study material concepts independently so that the learning activities carried out become more optimal. Research by Parhusip & Hardini (2020) states that a contextual approach can increase activity, collaboration, and a comfortable learning atmosphere for students. A contextual approach in video animation can shape abstract material concepts into more concrete ones.

Abstract material concepts can be found in chemistry subjects, especially redox material. Redox material's characteristics are symbolic, macroscopic, and microscopic aspects (Sukmawati, 2019). Macroscopic and symbolic aspects of redox reaction material tend to be easily understood by students, but microscopic aspects often raise students' doubts (Hatimah & Khery, 2021). The release and capture of electrons, oxygen, and oxidation numbers are microscopic aspects that often make it difficult for students to learn redox material (Apriadi & Redhana, 2018). Research by Rizki et al. (2020) stated that 50.71% of students experienced misconceptions about redox reaction material. This fact is supported by research by Purwanto et al. (2022), who revealed that redox reactions are one of the most challenging chemical materials to understand during online learning. Therefore, learning media is needed in the form of videos easily accessible to students at school and home.

In line with research conducted by Nabila et al. (2023), Animaker can produce learning media that is useful for students and teachers. The animated videos developed can make it easier for students to understand the subject matter presented. In addition, chemistry teachers feel that there is an increase in the quality of learning by students when using exciting media. The research results of Mukasheva et al. (2023) also state that using a contextual approach can provide more excellent opportunities for designing effective technology-based learning media. Based on the description above, this study aims to develop animated videos with contextual content on redox reaction materials using web apps Animaker and know the products' quality.

Methods

The research is a type of research and development. This research aims to produce a valuable product and test the product's quality. The development model in this study is the 4D model developed by Thiagarajan et al. (1974), which includes define, design, develop, and disseminate stages. The 4D development model can be seen in Figure 1.

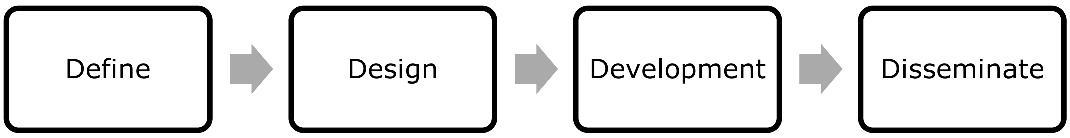

Figure 1. 4D development models

4D development model selection was because the research steps in this model were arranged in a complex and systematic manner so that it could meet the needs of the researchers in this study. The define stage consists of several stages of analysis, the first of which is needs analysis. Needs analysis was conducted through interviews and observations at MAN 1 Yogyakarta, MAN 2 Yogyakarta, SMA N 1 Gamping, and SMA N 8 Yogyakarta. Interviews were conducted to determine the use of learning media, characteristics of the material, student learning type, and constraints experienced by the teacher during the class. Next is learner analysis, which is composed of student analysis related to students' difficulties and attitudes during learning at school and at home. Based on the results of the two processes, the concept process is carried out as an analysis to analyze the material that will be included in the learning media. The definition stage ends with tasks analysis which provides an analysis of indicators, material components, and learning objectives that will be explained.

The design stage includes the media selection process to identify appropriate learning media according to the needs analysis from the define stage and the selection of supporting web apps. Then, it is continued with the selection format process to design the flow of presentation of the material and content of the learning media being developed. The following design stage is the reference collection, namely the collections of redox material from various sources, including printed books, online literature reviews, to consultations with an expert. The design phase ends with the initial process design, namely the product design process, such as preparing a video narrative, making animated videos, synchronizing audio videos, final media completion process, qualifying questions, and designing assessment instruments.

The development stage consists of several processes, such as expert appraisals and testing. The expert appraisal process is carried out by evaluating the product with material and media experts to obtain product quality assessment results. Product quality assessment is carried out using a Likert scale instrument with a column of criticism and suggestions for improving the product being developed. Furthermore, in the development testing process, an assessment was carried out by a reviewer (high school chemistry teacher) using the Likert scale instruments and limited trials is carried out to class X high school students using the Gutman scale instruments. The Gutman scale instrument in the student response test consists of positive and negative statements in each aspect. The average scores from the results of the assessment and student response tests are calculated using the following equation:

$$\overline{X} = \frac{\sum x}{n} \qquad (1)$$

Remarks:
$\overline{X}$: average scores
$\sum x$: total score
n : number of appraisers

The score obtained will be converted into a qualitative score with a total assessment classification, as seen in Table 1.

Table 1. Criteria category total assessment

No	Quantitative Score Range (i)	Category Qualitative
1.	X > Xi + 1.80 SBi	Very good
2.	Xi + 0.60 SBi < X ≤ Xi + 1.80 SBi	Well
3.	Xi – 0.60 SBi < X ≤ Xi + 0.60 SBi	Enough
4.	Xi – 1.80 SBi < X ≤ Xi - 0.60 SBi	Not enough
5.	X ≤ Xi – 1.80 SBi	Very less

The data will then be processed in the form of a score, and the percentages of product ideality will be calculated by dividing the score obtained with the ideal maxium score. Then the data obtained is processed into qualitative with the criteria in Table 2.

Table 2. Data interpretation

No	Information (%)	Score
1	0 – 20	Very Not Good
2	21–40	Not good
3	41–60	Pretty good
4	61–80	Well
5	81 - 100	Very good

The dissemination stage consists of packaging, diffusion, and adoption. The packaging process comprises product packaging processes to make them more effective and user-friendly. Product packaging is carried out by uploading the product on the youtube and google drive platforms. With the proper packaging process, more parties can utilize research products. While the diffusion and adoption processes consist of product dissemination to chemistry teachers and students at MAN 1 Yogyakarta, MAN 2 Yogyakarta, SMA N 1 Gamping, and SMA N 8 Yogyakarta so that they can b adopted, studied, and used during learning.

Results and Discussion

The research was conducted using the 4-D development model developed by Thiagarajan (1974). The research process carried out is as follows:

Define

The define stage includes an analysis of the needs of the product to be developed. Needs analysis relates to the learning process, learning media, and the chemistry material taught. Needs analysis was carried out at MAN 1 Yogyakarta, MAN 2 Yogyakarta, SMA N 1 Gamping, and SMA N 8 Yogyakarta. Based on the results of observations and interviews, information was obtained that the learning media used by the teacher generally in the form of textbooks, powerpoints, and material summaries. The selection of learning media is based on the ease of access to teaching in class. The teacher has used learning media in videos originating from youtube. However, the video used differs from the material teachers want to convey in class, so learning using video is no longer carried out. Teachers also still find it challenging to make learning videos independently (Bruggeman et al., 2022). The teacher explains that they have yet to learn the method of exciting video creation. In addition, the use of textbooks can cause misconceptions if students learn independently. Misconceptions can be caused because the discussion contained in textbooks is still too complex (Afifah et al., 2023). PowerPoint media is also still not optimal for presenting abstract redox material. Media PowerPoint cannot explain the microscopic aspects of redox reaction materials. Based on a literature review, data was obtained that 50.71% of students had misconceptions about redox reaction material (Rizki et al. al, 2020). The interview results also stated that the use of learning media above resulted in learning centralized only to the teacher. Interesting learning could be pushed with the use of interactive learning media. One of the interactive learning media could be embodied with arranged media on audio, video, text, images, and animation to help deliver theory (Nurlatifah & Suprihatiningrum, 2023).

When viewed from the perspective of high school students, using learning media such as textbooks does not inspire students enough because the material is still quite complex. Students need learning media that is simpler and easier to understand (Ikhsannudin, 2022). According to the results of student interviews, the most challenging redox reaction material can be found in the sub-chapter of rules and determination of oxidation numbers. For example, students are often confused when determining the oxidation number of hydrogen is +1 and -1. Therefore, students will look for alternative learning materials and media for independent learning. In addition to learning media, a possible approach is needed to make it easy for students to understand the redox theory, which is the contextual approach. Approach contextual own role urgent in development education. Subject matter with payload contextual could give knowledge to students related to its application in daily life. Knowledge in a contextual manner could prove that knowledge chemistry is very sticky with human life (Nurhana et al., 2022). The chemistry teacher explained that a contextual approach is essential for used moment learning so that theory feels more effective and valuable. Based on the needs of students and teachers in learning, an animated video learning media was developed with a payload contextual to the material reaction redox.

Design

The design stage comprises the product design process based on the needs analysis results at the define stage. The product design includes determining the type of learning media, content, and assessment instruments. Based on the results of the define stage, the instructional media developed is an animated video containing a contextual approach to redox reaction material. Animated video learning media has many advantages, such as being easy to access, increasing student interest in learning, and can be designed according to the desired explanation of the material (Hanif, 2020). Planning activities are completed by compiling a material framework, content, delivery flow, supporting animations, practice questions, selecting devices to be used, and assessment instruments. The material's content is adjusted to the revised 2017 edition of the 2013 chemistry curriculum on Basic competency 3.9, which focuses on redox reaction material in high school class X. Material preparation was carried out by reviewing several chemistry subject books and relevant digital literature. The preparation of the material was also consulted by experts to avoid misconceptions.

The hardware used in the design stage is laptops and smartphones. Laptops are used for editing and creating animated videos. Smartphones are used for data transfer and audio recording. Software used in this study includes web apps Animaker, Wondershare Filmora, Adobe Illustrator 2020, Canva, and google drive. Web apps Animaker is used for preparing animated videos because it has many supporting animations that can be utilized (Paino & Hutagalung, 2022). Wondershare Filmora is used to combine audio and visuals from animated videos that have been compiled. Adobe Illustrator 2020 and Canva are used for compiling graphic designs and selecting animation support materials like gifs. Meanwhile, google drive stores important files from developed learning media and a container for storing animated videos. The supporting websites used are www.remove.bg to remove the background from images, www.unscreen.com to remove the background from videos or gifs, and www.bit.ly.com to shorten links and convert links to be quick response code that will be used.

Designing animated videos is carried out by accumulating material, designing video components, writing video narrator scripts, compiling animated videos through web apps Animaker, audio-video synchronization, and finishing process. Designing an animated video starts with preparing and analyzing redox reaction material. The material analysis aims to determine the material's characteristics and the depth of the material to be presented. Redox reaction material that will be presented includes 1) a Definition of redox reactions, 2) a Classification of redox reactions, 3) a Definition of oxidation numbers, 4) a Determination of oxidation numbers, 5) a Determination of changes in oxidation numbers, 6) Determination of oxidizing agents, reducing agents, oxidation products, and reduction products, and 7) Application of redox reactions in everyday life. After the material is prepared, determine the animated video's components. Animated video components consist of opening, content, and closing. The process continues with writing video scripts based on predetermined materials and components. Narrative scripts are tailored to the needs of researchers in making animated videos. The narrative script is then recorded using a smartphone, and the data is transferred to a laptop for synchronization.

The following process is in the form of preparing animated videos using web apps Animaker. Compiling the video begins with creating an animated visualization following the script design and predetermined components. The process of making an animated video can be seen in Figure 2.

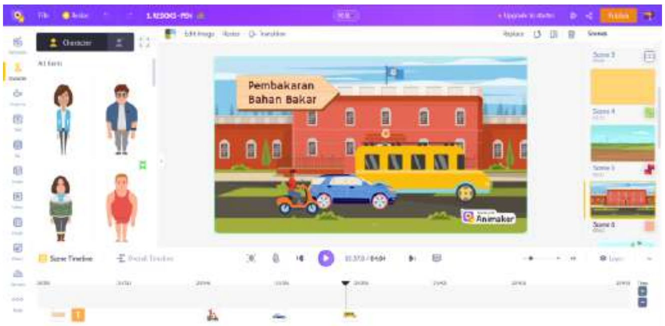

Figure 2. The process of making animated videos through web apps Animaker

Animation customized with discussion medium material delivered. Making an animated video is continued by designing fragments on the opening, content, and closing components. The opening component of the animated video is the initial part composed of the title, learning objectives, apperception, and stimulus. The form of the initial display can be seen in Figure 3.

Figure 3. Video opening section

The next component is content. The content section comprises the textual and contextual presentation of material, examples of questions and solutions, and practice questions that students can access. The display of the contents section can be seen in Figure 4.

Figure 4. Content section

The last video component is the closing. The closing section consists of concluding material, information related to the following video, and acknowledgments. The cover display can be seen in Figure 5.

Figure 5. Closing section

The animated video comprises six videos discussing each redox reaction sub-material. Each video is animated consisting of audio material and character explanations working animation to clarify the delivery of redox reaction material. Redox reaction material is presented in detail, depth, and combined with a contextual approach. The process of delivering the material is done by presenting supporting characters and animation. The animated characters are like the teacher's character, with body movements explaining the material. Inserted pictures and animated characters aim to illustrate the material. For example, as in the explanation of rusty iron, an animation describes the iron's color change from silvery gray to yellow-brown. In addition to animation, this learning media is also equipped with contextual content. Contextual content can help students to find out the benefits of the material being taught by applying it to everyday life (Mubarok et al., 2022). Based on a literature review, there have been several studies on developing animated video learning media, such as those conducted by Asrori et al. (2021) and Dewi & Kamaludin (2022). Based on similar research that has been done, it is still rare to find the preparation of animated video learning media using web apps Animaker and contextual loading on redox reaction material. Therefore, the development of this product is given contextual content as an update from similar research.

Contextual content consists of 7 components: asking, finding, constructivism, modeling, learning communities, reflection, and actual assessment (Sujiono et al., 2023). However, in this research product, only five contextual components are presented. The material in this animated video is presented without actual assessment and constructivism components, so it is limited to reflection.

The assessment component actually and constructivism will be more effective if directly applied to the learning process in the classroom. This is because the actual assessment requires information related to student development from the beginning to the end of learning (Kosimov, 2022). It is quite difficult to observe if it is only in the form of media development (Khairunnisa et al., 2020). The asking component in the animated video is presented in the form of an opening question as a stimulus for students. The purpose of giving questions at the beginning of the video is so that students can connect events that have been experienced in everyday life with the material to be studied. The appearance of the asking component can be seen in Figure 6.

Figure 6. Asking component

The find component relates to the ask component. From the asking component, students are encouraged to find answers so that the finding component is indirectly adapted to the media. Activity finds accompanied by exposure theory reaction possible redox found daily in life. Several example theories loaded context that is rooting iron, decay apples, burning process, and utilization of compound redox in life every day. The display of the find component can be seen in Figure 7.

Figure 7. Find component

The modeling component is adapted as an example of applying the material in practice textual and discussion of questions (Rachmawati et al., 2020). Example application theory in a textual manner could be designed with a gift example question. Then next, with discussion and methods fast for complete question given. The appearance of the modeling components in this product can be seen in Figure 8.

Figure 8. Modeling component

The components of the learning community are adapted in the form of assignments or materials that can be discussed with peers (Ismayani et al., 2019). The discussion material in this animated video is application material in daily life and gift questions. Ten questions related to the whole redox reaction material are presented to be able to discuss Becomes ingredients for the student. The question given consists of knowledge textual and contextual. Presentation practice about done via Google Forms and can be accessed via the link as well as quick response (QR) code which can be seen in Figure 9.

Figure 9. Learning community component

The reflection component is adapted into an animated video in the form of material reinforcement and conclusions from what has been learned (Aulia, 2019). The conclusion of each discussion is inserted at the end of the video as part of the closing, which can be seen in Figure 10.

Figure 10. Reflection component

After the animation preparation is complete, the audio synchronization with the animated video is carried out. The synchronization process uses the Wondershare Application Filmora to facilitate the editing process. Apart from inserting audio narration, during the synchronization process, it is also accompanied by providing a backsound. Giving background aims to create a cheerful atmosphere in the developed animated video (Hapsari et al., 2019). The audio-video synchronization process can be seen in Figure 11.

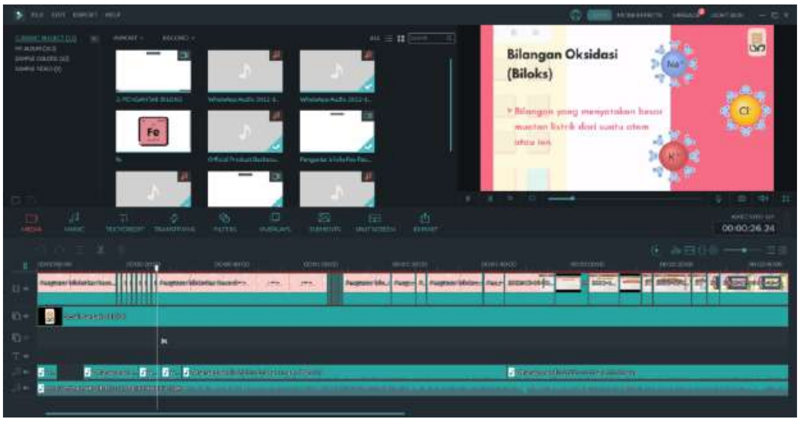

Figure 11. Audio-video synchronization process

The process of preparing the animated video ends with the video publication stage. The format used in this animated video is .mp4, with a screen resolution of 1334 x 750. The resulting screen resolution is already at a high standard definition (HD), so the resulting video will be clear when watched. For easy access, videos are uploaded via google drive and youtube. Animated videos were submitted to the lecturer mentor for correction and then could be repaired based on the correction of the results.

After the video is finished, the following process is making research instruments. The research instruments developed consisted of two types: product quality assessment instruments and student responses. The product quality assessment instrument was developed using the Likert scale, while the instrument for student responses used the Guttman scale. Aspects assessing product quality include materials, videos, and contextual content. At the same time, aspects for student responses consist of material aspects, presentation, animation, contextual content, and benefits. Instrument experts validate instruments that have been made.

Develop

Based on the results correct from the lecturer, conducted repair product to generate product revision. Product revision was then evaluated by three peer reviewers, validated by one material expert, one media expert, and four reviewers, and then responded to by twenty high school students in grade X. The results of the product quality assessment and student responses can be seen in Table 3.

Table 3. Data on product quality assessment results and student responses

Assessment/Response	Assessment Aspect	∑ Scores	∑Ideal Maximum Score	Ideal Percentages	Categories
Material experts	Theory	14	15	92	Very Good
	Contextual	9	10		
Media expert	Videos	18	20	90	Very Good
Reviewer	Material	19	20	95.6	Very Good
	Contextual	19	20		
	Videos	19.25	20		
Student	Theory	8.5	10	94.5	Very Good
	Presentation	9.25	10		
	Animation	10	10		
	Contextual	10	10		
	Benefit	9.5	10		

Based on Table 3 it is known that the results of the assessment by material experts obtained an ideal percentage of 92% in the very good category. Those results state that the developed product has depth, sufficient material, appropriate language, and good plot delivery. Depth material and appropriate language usage could make presentation knowledge more easily accepted by students (Panjaitan et al., 2020). In addition, material experts provide suggestions by adding institutional logos and corrections related to practice questions and learning objectives. Suggestions are made in the improvement process so the developed product can load suitable content. Based on the evaluation expert material, got concluded that the material and payload of the contextual animation in the video are very appropriate and appropriate for help explanation material. The media expert's assessment obtained a result of 90% in the very good category. Those results state that animated video covers good audio and video aspects. Media experts also provide suggestions regarding the choice of colors that must contrast between the text and the image or video background. Election contrasting colors could increase attention audience and quality exposure theory (Sugiyanto et al., 2022). Product evaluation by reviewers obtained an ideal percentage of 95% in the very good category. Reviewers also provide suggestions and input, such as the selection of animated characters that can be readjusted to the ongoing material, and the size of the text used can be enlarged so that it is more explicit. Based on the results of assessments from material experts, media experts, and reviewers, data is obtained that the animated video developed has an excellent category. So, the animated video can be used as an option and interest learning media in material redox reactions well in class or moment study independently.

Class X high school students then responded to the redox animated video material. Based on the results of student responses, the animated video learning media developed obtained an ideal percentage of 94.5% in the very good category. Response results from students stated that theory with payload contextual gives more impression meaningful and easily understood by students. Corresponding with the research (Budiman et al., 2021), payload contextual could help deliver material about application knowledge in everyday life. In addition, it is also known that the animation used can help visualize abstract redox reaction material (Naimah, 2022). Then, students also stated that animated videos helped increase students understanding when studying individually or in groups.

Dissemination

The dissemination stage is carried out so many parties can feel the product's benefits in animated videos. Product packaging is carried out by uploading an animated video to a youtube account so students can access it. Besides going through youtube, product packaging also uses google drive with the link https://bit.ly/AnimasiReaksiRedoksX. The research products were distributed to chemistry teachers and students at MAN 1 Yogyakarta, MAN 2 Yogyakarta, SMA N 1 Gamping, and SMA N 8 Yogyakarta. Product dissemination aims to enable video-animation learning media to be adopted, studied, and used during learning (Harun et al., 2023).

Based on the development, this animated video learning media benefits teachers and students. For teachers, this animated video learning media can be used as a material supplement, alternative learning media, and assignments (Fadhli, 2022). The ease of access to the animated videos developed is also an added value for teachers because they are easy to use (Pratama et al., 2022). This animated video can help students visualize the relationship between redox reaction material and phenomena in everyday life. According to the students, the developed animated video learning media contained complete and easy-to-understand explanations. Animated videos can also reduce students' boredom while learning (Safitri et al., 2021). Packaging engaging animation could push students to focus and study deeply (vans Alten et al., 2019). Students also find it easy to use animated videos because they are available on youtube and google drive and can be accessed via the links provided at any time.

Conclusion

The product developed is an animated video with contextual content on redox reaction material using Web Apps Animaker. The development process is carried out with 4D stages. Developed animated video arranged on component opening, content, and closing. Rection material redox served with payload contextual. Component contextual content loaded in the animated video is asking, finding, modeling, community study, and reflection. Animated video learning media benefits teachers and students during activity learning because it could help explain theory reaction abstract redox becomes more concrete. Based on the results of the assessment, this animated video obtained an ideal percentage of 92% from material experts in the very good category, 90% of media experts in the very good category, 95% of the reviewers in very good category, and 94.5% of the student response test with very good category. Thus, the animated video is of very good quality and feasible to be used as an alternative learning media on redox reaction material in classroom learning.

References

Afifah, N., & Isnawati, I. 2022. Profil miskonsepsi buku teks pelajaran biologi kurikulum 2013 dan penyelesaiannya pada materi evolusi. *Berkala Ilmiah Pendidikan Biologi*, 12(1):032-043. Retrieved from https://ejournal.unesa.ac.id/index.php/bioedu/article/view/47268.

Anggraeni, A.Y., Wardani, S., & Hidayah, A.N. 2020. Profil peningkatan kemampuan literasi kimia siswa melalui pembelajaran inkuiri trebimbing berbasis kontekstual. *Jurnal Inovasi Pendidikan Kimia*, 14(1):2512–2523. https://doi.org/10.15294/jipk.v14i1.18979.

Angjelina, P. & Asrizal, A. 2019. Efek LKS IPA bermuatan literasi saintifik tema kesehatan pencernaan dalam model pembelajaran kontekstual adaptif pada hasil belajar siswa kelas viii SMPN 7 Padang. *Pillar of Physics Education*, 12(1):193–200. https://doi.org/10.24036/4938171074

Apriadi, N.N.S. & Redhana, I.W. 2018. Identifikasi miskonsepsi siswa kelas X pada topik reaksi redoks. *Jurnal Pendidikan Kimia Indonesia*, 2(2):70–77. https://doi.org/10.23887/jpk.v2i2.16617.

Apriansyah, M.R. 2020. Pengembangan media pembelajaran video berbasis animasi mata kuliah ilmu bahan bangunan di program studi Pendidikan Teknik Bangunan Fakultas Teknik Universitas Negeri Jakarta. *Jurnal Pensil: Pendidikan Teknik Sipil*, 9(1):9–18. https://doi.org/10.21009/jpensil.v9i1.12905.

Asrori, Suryani, N., & Drajati, N.A. 2021. Development of animation video on youtube channels as an alternative learning media during the Covid-19 pandemic. *JTP - Jurnal Teknologi Pendidikan*, 23(3):285–294. https://doi.org/10.21009/jtp.v23i3.23679

Aulia, V. 2019. Refleksi pelaksanaan pembelajaran pada praktik mengajar mahasiswa di jenjang SD sederajat untuk mata pelajaran bahasa inggris. *Briliant: Jurnal Riset dan Konseptual*, 4(3):359–378. https://doi.org/10.28926/briliant.v4i3.355

Budiman, A., Samani, M., Rusijono, Setyawan, W.H., & Nurdyansyah. 2021. The development of direct-contextual learning: a new model on higher education. *International Journal of Higher Education*, 10(2):15–26. https://doi.org/10.5430/ijhe.v10n2p15

Bruggeman, B., Garone, A., Struyven, K., Pynoo, B., & Tondeur, J. 2022. Exploring university teachers' online education during covid-19: Tensions between enthusiasm and stress. *Computers and Education Open,* 3(100095). ttps://doi.org/10.1016/j.caeo.2022.100095

Bulkani, B., Fatchurahman, M., Adella, H., & Setiawan, M.A. 2022. Development of animation learning media based on local wisdom to improve student learning outcomes in elementary schools. *International Journal of Instruction*, 15(1):55–72. https://doi.org/10.29333/iji.2022.1514a

Daulay, R.S., Pulungan, H., Noviana, A., & Hurhaliza, S. 2020. Manfaat teknologi smartphone dalam kegiatan pembelajaran pendidikan islam di masa pandemi Corona-19. *Al-Ulum: Jurnal Pendidikan Islam*, 1(1):29–43. https://doi.org/10.56114/al-ulum.v1i1.7

Dewi, A.M. & Kamaludin, A. 2022. Development of audiovisual-based PowToon animation video on chemical bonds for tenth grade. *Jurnal Penelitian Pendidikan IPA*, 8(1):222–229. https://doi.org/10.29303/jppipa.v8i1.865.

Dewi, L. & Dwikoranto, D. 2021. Analisis pendekatan pembelajaran contextual teaching and learning (CTL) terhadap peningkatan hasil belajar fisika dengan metoda library research. *Pendipa: Journal of Science Education*, 5(2):237–243. https://doi.org/10.33369/pendipa.5.2.237-243

Fadhli, M. 2022. Optimize learning process during the Covid-19 pandemic through IT-based learning media at SMPN 10 Bengkulu. *Jurnal Pengabdian kepada Masyarakat,* 6(1):243-251. https://doi.org/10.29062/engagement.v6i1.758

Firmadani, F. 2020. Media pembelajaran berbasis teknologi sebagai inovasi pembelajaran era revolusi industri 4.0. *KoPeN: Konferensi Pendidikan Nasional*, 2(1):93–97. Retrieved from https://ejurnal.mercubuana-yogya.ac.id/index.php/Prosiding_KoPeN/article/view/1084

Hanif, M. 2020. The development and effectiveness of motion graphic animation videos to improve primary school students' sciences learning outcomes. *International Journal of Instruction*, 13(3):247–266. https://doi.org/10.29333/iji.2020.13416a

Hapsari, A.S., Hanif, M., Gunarhadi, & Roemintoyo. 2019. Motion graphic animation videos to improve the learning outcomes of elementary school students. *European Journal of Educational Research*, 8(4):1245–1255. https://doi.org/10.12973/eu-jer.8.4.1245

Harun, F.E., Panai, A.H., & Arifin, I.N. 2023. Development of steam-base interactive learning media on energy sources and its utilization in class IV Elementary School, Tilamuta District, 10(1):69-79. https://doi.org/10.17605/OSF.IO/86XV9

Hatimah, H. & Khery, Y. 2021. Pemahaman konsep dan literasi sains dalam penerapan media pembelajaran kimia berbasis android. *Jurnal Ilmiah IKIP Mataram*, 8(1):111–120. Retrieved from https://e-journal.undikma.ac.id/index.php/jiim/article/view/4078/2777

Ikhsannudin, M.M. 2022. Development of a simple micriscope from used goods as a science learning media. *Indonesia Journal of Applied Research,* 3(2):131-140. https://doi.org/10.30997/ijar.v3i2.220

Khairunnisa, I., Desnita, D., Putra, A., & Hidayati, H. 2020. Analisis sajian buku teks pelajaran fisika SMA kelas XII semester 2 terkait komponen contextual teaching and learning (CTL). *Pillar of Physics Education*, 13(1):17–24. https://doi.org/10.24036/7964171074

Kis, K., Kirana, C., Romadiana, P., Wijaya, B., Supardi, & Raya, A.M. 2021. Peningkatan sumber daya manusia melalui pembuatan video pembelajaran bagi guru-guru. *ADI Pengabdian Kepada Masyarakat*, 1(2):1–7. https://doi.org/10.34306/adimas.v1i2.423

Kosimov, A., 2022. The importance of choosing appropriate assessment tools in language teaching and its impact to secong language acquisition. *British View,* 7(1):14-32. 10.5281/zenodo.5847595

Mubarok, H., Sofiana, N., Kristina, D., & Rochsantiningsih, D. 2022. Meaningful learning model through contextual teaching and learning; the implementation in english subject. *Jurnal Linguistik Terapan dan Pendidikan Bahasa Inggris,* 9(1):25-34. https://doi.org/10.34001/edulingua.v9i1.3159

Muhammad, H., Murtinugraha, R.E., & Musalamah, S. 2020. Pengembangan media pembelajaran e-learning berbasis moodle pada mata kuliah metodologi penelitian. *Jurnal Pensil: Pendidikan Teknik Sipil*, 9(1):54–60. https://doi.org/10.21009/jpensil.v9i1.13453

Mukasheva, M., Kornilov, I., Beisembayev, G., Soroko, N., Sarsimbayeva, S., & Omirzakova, A. 2023. Contextual structure as an approach to the study of virtual reality learning environment. *Cogent Education*, 10(1):2165788. 10.1080/2331186X.2023.2165788

Munawar, B., Hasyim, A.F., & Ma'arif, M. 2020. Pengembangan bahan ajar digital berbantuan aplikasi animaker pada PAUD di Kabupaten Pandeglang. *Jurnal Golden Age*, 4(2):310–321. https://doi.org/10.29408/goldenage.v4i02.2473

Myori, D.E., Chaniago, K., Hidayat, R., Eliza, F., & Fadli, R. 2019. Peningkatan kompetensi guru dalam penguasaan teknologi informasi dan komunikasi melalui pelatihan pengembangan media pembelajaran berbasis android. *JTEV (Jurnal Teknik Elektro dan Vokasional)*, 5(2):102–109. https://doi.org/10.24036/jtev.v5i2.106832

Nabila, H.I., Fitriani, N., & Setiawan, W. 2023. Pengembangan media pembelajaran video animasi menggunakan animaker pada materi statistika. *Jurnal Pembelajaran Matematika Inovatif*, 6(3):1071-1082. 10.22460/jpmi.v6i3.17563

Naimah, A. 2022. The use of video as a learning media in science learning (a systemic review). *Al-Ishlah Jurnal Pendidikan,* 14(4):6941-6950. https://doi.org/10.35445/alishlah.v14i4.1565

Nurhana, L., Peringaninangin, H., & Mardani, D. 2022. Implementasi pendekatan kontekstual dalam pembelajaran tematik siswa kelas IV Madrasah Ibtidaiyah. *Jurnal Riset Rumpun Ilmu Bahasa*, 1(2):73-83. https://doi.org/10.55606/jurribah.v1i2.392

Nurlatifah, N. & Suprihatiningrum, J. 2023. Pengembangan google sites berbasis inkuiri terbimbing pada materi asam basa sebagai media belajar mandiri siswa SMA/MA kelas xi. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1):67–83. https://doi.org/10.24815/jpsi.v11i1.27391

Nurrita, T. 2018. Pengembangan media pembelajaran untuk meningkatkan hasil belajar siswa. *Misykat: Jurnal Ilmu-Ilmu Al-Quran Hadits Syariah dan Tarbiyah*, 3(1):171–210. https://doi.org/10.33511/misykat.v3n1.171

Panjaitan, R.G.P., Titin, T., & Putri, N.N. 2020. Multimedia interaktif berbasis game edukasi sebagai media pembelajaran materi sistem pernapasan di kelas XI SMA. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(1):141–151. https://doi.org/10.24815/jpsi.v8i1.16062

Paino, N.P. & Hutagalung, T. 2022. Developing biographical texts by audio-visual teaching materials: Animaker-Web for hugh school students. *Utamax: Journal of Ultimate Research and Trends in Education,* 4(3):228-245. https://doi.org/10.31849/utamax.v4i3.11125

Parhusip, Y.P. & Hardini, A.T.A. 2020. Meta analisis efektivitas pembelajaran konteks tual terhadap kemampuan pemahaman matematika bagi siswa Sekolah Dasar. *Mimbar Ilmu*, 25(3):319–326. https://doi.org/10.23887/mi.v25i3.27954

Pratama, T.A., Alim, J.A., & Hermita, N. 2022. Pengembangan video animasi geometri kelas ii di Sekolah Dasar. *el-Ibtidaiy: Journal of Primary Education*, 5(2):205-220. 10.24014/ejpe.v5i2.18907

Purwanto, K.K., Faizah, F., & Nurillah, H.S. 2022. Analisis kesulitan belajar kimia dalam pembelajaran daring selama masa pandemi Covid-19. *Unesa: Journal of Chemical Education*, 11(1):14–22. https://doi.org/10.26740/ujced.v11n1.p14-22

Rachmawati, B.A., Purwanto, S., & Sari, P. 2020. Pengaruh model pembelajaran kooperatif tipe two stay two stray (TSTS) dengan pendekatan kontekstual terhadap kemampuan pemahaman konsep matematis siswa di SMP Negeri 169 Jakarta. *Jurnal Riset Pendidikan Matematika Jakarta*, 2(2):59–70. https://doi.org/10.21009/jrpmj.v2i2

Rasagama, I.G. 2020. Pengembangan model pembelajaran getaran berbasis video youtube untuk meningkatkan pemahaman konsep mahasiswa politeknik. *Jurnal Pendidikan Sains Universitas Muhammadiyah Semarang*, 8(2):91–101. https://doi.org/10.26714/jps.8.2.2020.91-101

Rizki, M., Nurhadi, M., & Widiyowati, I.I. 2020. Penerapan model pembelajaran berbasis masalah untuk menurunkan miskonsepsi siswa tentang konsep reaksi redoks. *Jurnal Zarah*, 8(1):14–20. https://doi.org/10.31629/zarah.v8i1.1974

Safitri, D., Lestari, I., Maksum, A., Ibrahim, N., Marini, A., Zahari, M., & Iskandar, R. 2021. Web-based animation video for student environmental education at Elementary Schools. *International Journal of Interactive Mobile Technologies (IJIM)*, 15(11):66–80. https://doi.org/10.3991/ijim.v15i11.22023

Salsabilla, U.H., Agustin, A., Safira, F., Sari, I., & Sundawa, A. 2021. Manfaat teknologi bagi mata pelajaran PAI di masa pandemi covid-19. *Edunesia: Jurnal Ilmiah Pendidikan*, 2(1):125–132. https://doi.org/10.51276/edu.v2i1.93

Sari, A.K., Ramansyah, W., Siradjuddin, I.A., & Ningsih, P.R. 2020. Pengembangan kompetensi guru SMKN 1 Labang Bangkalan melalui pembuatan media pembelajaran augmented reality dengan metaverse. *Jurnal Pengabdian Pada Masyarakat*, 4(1):52–59. https://doi.org/10.20956/pa.v4i1.7620

Setiawan, R., Mardapi, D., Pratama, A., & Ramadan, S. 2019. Efektivitas blended learning dalam inovasi pendidika era industri 4.0 pada mata kuliah teori tes klasik. *Jurnal Inovasi Teknologi Pendidikan*, 6(2):148–158. https://doi.org/10.21831/jitp.v6i2.27259

Sugiyanto, L., Anggiat, T., & Handoko, A. 2022. Analisis desain poster media promosi diklat 3 in 1 di Balai Diklat Industri Denpasar. *Jural Desain,* 2(1):143-155. http://dx.doi.org/10.33376/jdes.v2i1.1398

Sujiono, Andayani, Setiawan, B., & Wardani, N.E. 2023. The effectiveness of a textbook based on multicultural and contextual understanding as a learning material for scientific writing. *International Journal of Instruction*, 16(2):347–368. https://doi.org/10.29333/iji.2023.16220a

Sukmawati, W. 2019. Analisis level makroskopis, mikroskopis, dan simbolik mahasiswa dalam memahami elektrokimia. *Jurnal Inovasi Pendidikan IPA*, 5(2):195–204. https://doi.org/10.21831/jipi.v5i2.27517

Sunami, M.A., & Aslam, A. 2021. Pengaruh penggunaan media pembelajaran video animasi berbasis zoom meeting terhadap minat dan hasil belajar IPA siswa Sekolah Dasar. *Jurnal Basicedu*, 5(4):1940–1945. https://doi.org/10.31004/basicedu.v5i4.1129

Thiagarajan, S., Semmel, D., & Semmel, M. 1974. *Instructional development for training teachers of exceptional children*. Indiana University.

Toraman, Ç., Özdemir, H.F., Koşan, A.M.A., & Orakcı, Ş. 2020. Relationships between cognitive flexibility, perceived quality of faculty life, learning approaches, and academic achievement. *International Journal of Instruction*, 13(1):85–100. https://doi.org/10.29333/iji.2020.1316a

van Alten, D.C.D., Phielix, C., Janssen, J., & Kester, L. 2019. Effects of flipping the classroom on learning outcomes and satisfaction: a meta-analysis. *Educational Research Review*, 28:100281. https://doi.org/10.1016/j.edurev.2019.05.003

Yew Kai Wen, K., & Hua, Tan, K. 2020. ESL teachers' intention in adopting online educational technologies during covid-19 pandemic. *Journal of Education and E-Learning Research*, 7(4):387–394. https://doi.org/10.20448/journal.509.2020.74.387.394

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The Need Analysis of Ethno-Integrated Science Book Based on Pacu Jalur in Kuantan Singingi

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Abstract. Currently science learning has several problems including the lack of contextual material discussed, thus making science learning considered less interesting, monotonous, and difficult. This study aims to analyze the need for science learning contents used in schools to solve those problem. The research method used is a qualitative type of survey research. Data collection techniques were carried out through interviews with science teachers, student questionnaires, scientific literacy tests, and observations. The number of samples was 3 teachers and 47 students through cluster random sampling. The instruments used in this study included interview guidelines, questionnaires, learning observation sheets, and scientific literacy tests. Data analysis in this study used descriptive qualitative. Based on this needs analysis, the results obtained recommend the development of integrated science textbooks containing cultural content on the Pacu Jalur Kuantan Singingi, to be able to increase scientific literacy and cultural concern of students.
Keywords: Ethno-Integrated Science, Pacu Jalur Kuantan Singingi, Qualitiave Research, Need Analysis

Introduction

History records that the background to the emergence of science was due to human needs in life to solve everyday problems, so that this need prompted the birth of science as one of the general subjects in educational units to date (Widiyatmoko & Wiyanto, 2016). Science learning is a learning related to how to find out about natural phenomena systematically and has a close relationship with human life (Rahmiwati et al., 2018; Sarmi et al., 2019; Widiyatmoko & Wiyanto, 2016; Wilujeng, 2019). Natural science is essentially not only considered as mastery of a collection of knowledge in the form of facts, laws, and theories, but also a process of discovery which is expected to be a facility for students to learn about themselves, the natural environment, as well as prospects for further development in applying it in life (Handayani et al., 2018a, 2018b; Rumalolas et al., 2021; Wilujeng, 2019). The implementation of science subjects in schools is also part of the education system which is directed at being able to practice something based on the needs of students, so that it can assist them in gaining deeper, more meaningful experience, and understanding of the natural world around them scientifically (Dewi et al., 2017; Wilujeng, 2019).

Science learning in SMP/MTs currently carries several changes. One of the changes in this decade is the effort to strengthen the competency and achievements of students through the 2013 curriculum. Science learning in SMP/MTs, which was previously taught separately between scientific sub-discipline studies, has begun to be developed into an integration (Sarmi et al., 2019; Widiyatmoko & Wiyanto, 2016). Integrated science is a form of implementation of the essence of 21st century learning that packages holistically in each of its interdisciplines, such as physics, biology, chemistry, earth-space sciences, etc. (Asrizal et al., 2018; Mubita & Kalimaposo, 2016; Novitasari et al., 2017; Rinto et al., 2020; Wilujeng, 2019).

Integrated science has a broader meaning than previously known "IPA terpadu". Integrated science basically includes integration between science disciplines or integration of content, skills, attitudes, character, and even local potential with 3 main characteristics covering the dimensions of attitude, process, and product (Gusnedi et al., 2018; Rahmiwati et al., 2018; Wilujeng, 2019). This integration is expected to be able to create collaborative learning thematically and contextually, provides opportunities for students to learn and relate relevant science issues to their life, to get hands-on experience and apply science concepts that they are trying to find authentically and meaningfully through relationships between various concepts with one another without any gaps or overlapping between sub-disciplines (Asrizal et al., 2018; Rahmiwati et al., 2018; Widiyatmoko & Wiyanto, 2016; Yusnitasari & Isnaeni, 2019). The another goals and benefits of integrated science are also being able to train students to have the ability to solve problems, master the skills in the science field and social-spiritual abilities in a holistic, comprehensive manner, and be able to facilitate each of these skills effectively and efficiently (Gusnedi et al., 2018; Rahmiwati et al., 2018; Wilujeng, 2019).

The theory and expectations above have not been able to run smoothly. The Facts show that science learning that has been attempted so far has not been able to run well and maximally in junior high schools. One of these problems is caused by natural science material which should be packaged in an integrated based on the curriculum, but is still presented fragmented. Because of that, the essence of integration and linkage between natural science material doesn't appear in learning (Asrizal et al., 2018). This polemic also gave rise to a new round of problems, like monotonous learning and less attractive to students (Anderhag et al., 2016).

The stigma of the lack of interest in science cannot be separated from how learning has been taught. One of the reasons is that the science lessons taught are not accompanied by relevance and correlation to the relationship between the material being taught and the experiences and lives of students. The result of these problems is that students feel their learning is less interest, not contextual, and unmeaningful (Asrizal et al., 2018; Childs et al., 2015). This is coupled with the dominance of the western science paradigm which is still quite strong in many science learning resources in Indonesia, so that not many natural science learning resources are studied by students in accordance with the culture of life they experience (Ideland, 2018; Khaddour et al., 2017; Matsun et al., 2019).

As a source of learning, teaching materials are considered very important in becoming part of a learning process. Learning contents are defined as an essential tool needed by teachers to help and facilitate learning logically and systematically to increase the knowledge, competence, and abilities of students (Asrizal et al., 2018; Olayinka, 2016). Learning content specifically function to facilitate students in learning the content being taught, accommodate and become the main source of learning, provide specific ideas that are developed scientifically, and improve cognitive, affective, and psychomotor abilities (Asrizal et al., 2018; Yenni et al., 2017). The role of learning content must be maximized in the learning process (Olayinka, 2016; Saad, 2017). Giving a proportional portion of learning content also needs to be considered, because it will affect the mastery of knowledge, skills, even the development of confidence, and self-actualization of students in learning (Jeleelah et al., 2016; Saad, 2017).

One of the most common and popular learning tool and commonly used in science learning in SMP/MTs so far is textbooks. Textbooks are defined as printed learning resources that become a guide for students in supporting the process of learning activities. The existence of textbooks as the main learning material cannot be separated and replaced even though over time there are always progress and innovation (Handayani et al., 2019; Lestariningsih et al., 2021). Textbooks as the main learning tool in an educational strategy must be a reference that still refers to the curriculum (Kemendikbud, 2014; 2016). Textbooks are used to achieve basic competencies and increase the efficiency and effectiveness of student needs as determined by Ministry of Education (Kemendikbud, 2016; Rahmiwati et al., 2018). The role of textbooks in a lesson is expected to be able to bridge the teacher as a facilitator to invite students to gain knowledge and concepts in an applicable manner. Textbook also has function to facilitate students to explore and explore their various abilities (Mulyeni et al., 2019; Rumalolas et al., 2021).

Science books as a vital source of learning are still being adapted from western paradigm. Many values from Indonesian local wisdom have not been utilized as teaching references in schools, even though education policy in Indonesia provides opportunities to do it (Dwianto et al., 2017). One of the contributing factors is due to the teacher's obstacles in mastering the contents to develop the needs of science learning based on local wisdom (Ardianti et al., 2019). Based on the description above, this study aims to discuss and found out about what innovative learning science are desired and needed by teachers and students in in schools.

Methods

The method used is a survey qualitative research. The stages of the research include front end, student, curriculum, and learning contents analysis. Researchers collected data at a junior high school in Kuantan Mudik, Kuantan Singingi Regency, Riau in May 2022. The total sample of students was 47 people through cluster random sampling technique. Data collection was carried out through interviews with science teacher, learning observation, questionnaires and PISA scientific literacy tests by students. The data analysis technique used is quantitative descriptive. The results of these data are also strengthened by several relevant literature studies. The interview guide, questionnaires, and observation sheets can be seen in Tables 1, 2, and 3.

Table 1. Interview Guidelines.

Indicators	Number of Question Items
Learning Problems	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,
Characteristics of Learners	14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28,
Product Needs	29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39,

Table 2. Student Interest Questionnaire Grid.

Indicators	Number of Question Items
Learning Problems	1, 2, 3, 4, 5,
Characteristics of Learners	6, 7, 8, 9, 10, 11, 12, 13,14, 15, 16, 17, 18, 19, 20, 21,
Product Needs	22, 23, 24, 25, 26, 27, 28,29, 30, 31, 32, 33, 34, 35, 36

Table 3. Guidelines for Learning Observation Sheets.

Indicators	Number of Assesment Items
Learning Device	1, 2, 3,
Learning Process	4, 5, 6, 7, 8, 9, 10, 11, 12, 13,14, 15, 16,
Student Behavior	17, 18

As for the scientific literacy test instrument used in this study, it adopted the 2018 PISA test with 10 questions. In completing the data requirements for this research, the researchers also conducted an analysis of the curriculum and learning contents on the syllabus and some of the science textbook used. Through the analysis of the curriculum and learning content, it is hoped that it will be possible to map the contents and competency standards required by students in learning.

Results and Discussion

Front End Analysis

At this stage, the researcher conducted an investigation regarding the problems and constraints in learning science. Data collection in this analysis was carried out by conducting interviews with 3 science teachers, learning observation, and fiiled out questionnaires by 47 students. The first finding is that students consider science learning a difficult subject. This can be seen in Figure 1.

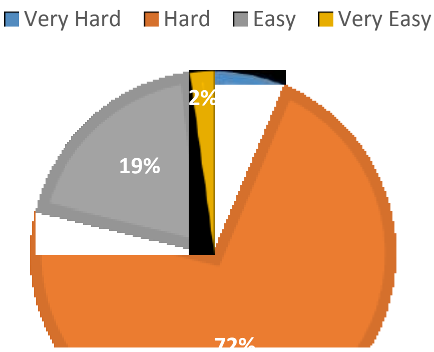

Figure 1. Student Assessment of Science Learning

The majority of students who filled out the questionnaire considered science as a difficult subject, and a small proportion of students considered learning science as an easy subject. There are several reasons that make students think science as difficult subject. This is caused by several difficulties and obstacles faced by students in the learning process, including 91.5% of students assessing science learning being taught is difficult to understand and not contextual and boring. The percentage 8.5% of students also think there is no science learning resources that are interesting and according to their needs. To validate those problem findings, the researcher triangulated the data obtained through interviews with science teachers and learning observation. The results show data that is not much different. Students do experience difficulties in understanding the science lessons being taught. This can also be seen when students work on assignments or exercises, inability to answer teacher questions, and liveliness in learning which is still rated low.

If these problems are considered in more detail, they actually have a relationship and influence each other. This is in accordance with research (Olayinka, 2016; Asrizal, et al., 2017; Ulandari et al., 2019) states that the learning resources are important elements that can affect the achievement of learning. Learning content can encourage effectiveness, efficiency, and practicality of learning in a more active. In this case, the lack of interesting and appropriate learning resources and contents made science learning be difficult for students.

Students Analysis

At this stage, researchers will explore the characteristics, abilities, interests, and needs of students. Data collection at this analysis stage was carried out by observation, filled out questionnaires, and tests. In connection with the problems that have been presented in the introduction and also found in the front-end analysis, such as science learnings which is considered less contextual, not relevant, uninteresting, and still dominated by western science. To validate those findings, the researcher conducted a scientific literacy test on students using several selected PISA questions. This test aims to see the extent to which students' abilities can relate the science material they are learning to their lives.

Scientific literacy is the ability that a person reflects reflectively in using his scientific knowledge to identify, interpret, explain, and conclude an issue and belief from a natural phenomenon or daily human activities based on empirical evidence through scientific concepts and facts (Fauziyah et al., 2021; Kade et al., 2019; OECD, 2019; Rostikawati & Permanasari, 2016; Siswanto et al., 2023; Soo-bum & Sei-Hill, 2018; Sukowati & Rusilowati, 2016). Scientific literacy is considered a basic ability that students really need to be able to master and exist in the current era of globalization (Fauziyah et al., 2021; Jufrida et al., 2019; Savitri et al., 2021; Suprianti et al., 2021). Scientific literacy is also a parameter that can determine the human resource development index in the education sector (Amrullah et al., 2021; Bröder et al., 2017; OECD, 2019). Scientific literacy which consists of 3 aspects including aspects of content, context, and competence will direct students to be able to solve and deal with various problems in everyday life (Fauziyah et al., 2021; Kade et al., 2019; Kähler et al., 2020; OECD, 2019).

Good science learning is study that can facilitate students to be able to master scientific literacy (Auerbach & Schussler, 2017). The most crucial part in increasing scientific literacy for students is strengthening the aspects of knowledge and understanding of science, scientific processes, and attitudes. Students are expected not only to know concepts, but also to be able to apply their scientific abilities in solving problems and finding solutions based on scientific considerations (Amrullah et al., 2021; Budiarti & Tanta, 2021; Savitri et al., 2021; Vieira & Tenreiro-Vieira, 2016).

The ideal condition above shows how important scientific literacy skills are for education, but in fact in Indonesia, this ability was still relatively low. Published data from 2005-2018 shows Indonesia is consistently ranked in the 10 lowest. In 2006-2012, Indonesia was only able to rank 64 out of 65, in 2015 it was ranked 62 out of 70, and in 2018 it was ranked 70 out of 78 countries. Of the 3 competency categories tested, Indonesia's scientific literacy scores always fluctuate and are below average with score ranges of 393, 383, 382, and 403, while in the last survey in 2018 Indonesia was only able to score 396 This fact illustrates that Indonesia's achievements in PISA are still far from the existing standards (Hikmawati et al., 2021; Kemendikbud, 2019; OECD, 2019; Rostikawati & Permanasari, 2016). Seeing the PISA result of Indonesia, the researchers conducted a test of students' scientific literacy in schools as research location. The purpose of this test is to see the results of scientific literacy skills in the school. These results will become a reference and be able to map out what kind of solution. The results of the scientific literacy test can be seen in Table 4.

Table 4. Results of Science Literacy Scores at Research Locations

Scores	Frequencies
0	9 Students
10	29 Students
20	8 Students
30	5 Students
40	1 Student

Based on the score data in Table 2, it shows that the scientific literacy of students in the junior high school research location was conducted was also very low. These results were also reinforced by interviews and observation in learning which showed that students' scientific literacy was same condition. If it is related to the findings of the previous problems, the low scientific literacy of students can be caused by a lack of contextual and meaningful science learning being taught. In connection with learning that is less contextual, science learning that is obtained through teaching resources or contents at school is considered to be less close to students' daily lives.

Several previous studies have provided many solutions to this problem. Experts consider it necessary to have innovation in learning, for example involving socio-cultural elements directly in learning science at schools (Dwianto et al., 2017; Østergaard, 2017; Zinyeka et al., 2016). The socio-cultural aspect is believed to be a part that is very relevant, close, and contains many values in human life (Huaman & Elizabeth, 2016; Wilujeng, 2016). This aspect can be one of the opportunities in strengthening more meaningful dan contextuall to science learning. This learning style is also expected to increase students' interest and learning achievements as well as the relevance of learning science for students (Setiawan et al., 2017; Zidny et al., 2020).

These social and cultural elements can be represented and referred to in the form of local wisdom that has grown and been rooted for a long time. Efforts to integrate local wisdom with science learning are considered to be able to help reconstruct and increase scientific knowledge through socio-cultural identities that have been attached to their lives (Atmojo et al., 2018; Rohmaan & Mukhibat, 2017). This opportunity can be utilized by the world of education to rebuild and create a learning environment that is close to the lives of Indonesian society, as well as a strategy to always emphasize more meaningful science learning for youth generation (Handayani et al., 2018a; Parmiti et al., 2021; Wilujeng, 2016).

Indonesia as a country that has a variety of cultures is considered to have the potential to be able to apply this learning system. Local cultural wealth that has been passed down from generation to generation will be an asset and a big challenge to be able to carry out the above solutions (Handayani et al., 2019; Parmiti et al., 2021; Zidny et al., 2021). This momentum is also supported by government policies through Statue of National Ministry of Education No. 22 of 2006 which states that local cultural wealth can be optimally utilized and managed by many parties. The goal is that this wealth has influence and contribution to the world of education, so that it is not just wasted with time (Dwianto et al., 2017; Prest et al., 2021; Setiawan et al., 2017), but also provide a significant impact and a real contribution in developing a close relationship between local wisdom, science, and education which so far were considered to have no correlation with each other (Dwianto et al., 2017; Zidny et al., 2021).

This innovation is also expected to increase the cultural concern of the younger generation. Along with the progress of the times, it is undeniable that the cultural concern is declining. Researchers conducted a survey of students through questionnaires and interviews with science teachers at one of the junior high schools in Kuantan Mudik regarding the cultural concern. The results of the survey and interviews show that, normatively, students do show cutural concern, but the concern are not deeply imbued. Students only know their culture in general and outside, but do not understand it fully and further. When referring to the true definition cultural concern was understood, applied, and developed these cultural values in real life. This concern will lead to responsiveness, care, and responsibility towards the preservation, inheritance, and development of existing cultural values (Eufrasia et al., 2019; Irmania et al., 2021; Parmiti et al., 2021; Purwanti, 2017; Tabi'in, 2017). The results of this study still show the low cultural concern of students in Kuantan Mudik.

Based on the results of the front end and student analysis above, the researcher concludes that teachers and students currently want an innovative teaching material that can be a solution to the various problems previously. The survey results of students through questionnaires and observations which were also reinforced through interviews with science teachers indicated that 91.1% of students stated that they needed to really need innovative learning. This innovation is expected to be different from the previous, more interesting, and can be a solution to improve the quality of learning.

When asked to students, 91.1% of them answered that the type of innovative learning contents wanted at this time were culture-based science textbooks. This culture-based textbook of course have to novelty, effectiveness, and practically. Textbooks are considered as a practical learning resource, don't require other learning tool for use, and can be used by anyone at any time. According to students and teachers, the existence of this culture-based textbook will be able to increase enthusiasm for learning, help students to understand learning better, increase scientific literacy and cultural concern of students. student's perceptsions of the need for Textbooks shown in Figure 2.

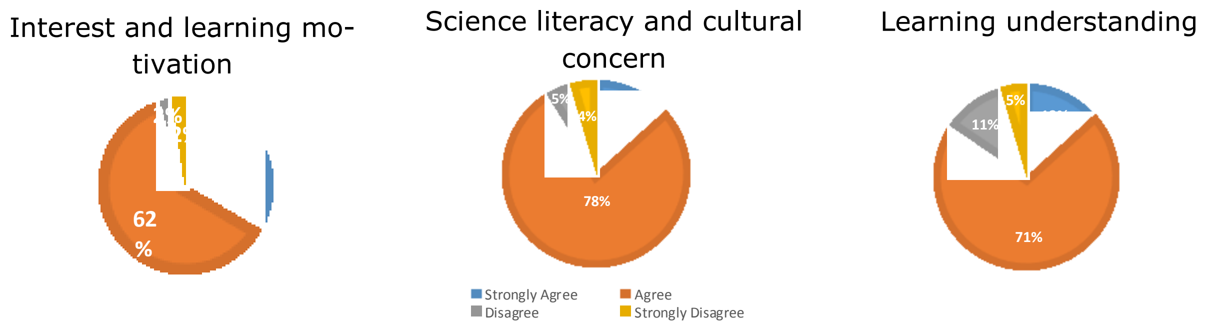

Figure 2. Student's perceptsions on the need of Textbooks

This is in accordance with the problems that occur, the low cultural concer of students, in theory it will certainly be resolved through the use of learning contents which are also developed on a culture-based basis. By containing content that is close to life, such as culture, this textbook is expected to increase the relevance and contextuality of learning science. Thus, students' scientific literacy abilities will also be optimized (Sukmawati, 2017). To complete this solution, researchers asked questions through questionnaires which culture was most popular and interested in students. Presented are 3 popular cultural options in the Kuantan Singingi district, especially Kuantan Mudik, namely Pacu Jalur, Perahu Baganduang, and Randai. The results of this poll can be seen in Figure 3.

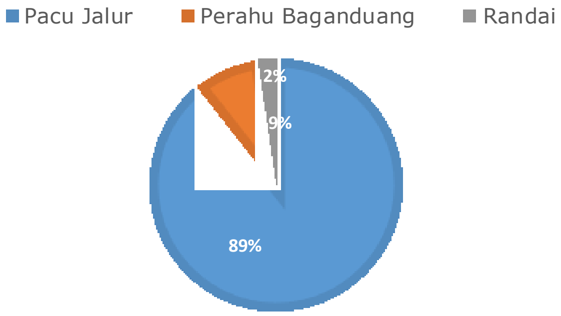

Figure 3. Student's Cultural Interest

Based on the results of the survey in Figure 3, the culture that is most interesting by students to be included in learning content is Pacu Jalur. Pacu Jalur in the Rantau Kuantan Malay languange has the meaning of a cultural festival of traditional rowing boat races with a length of 25-40 m and is filled by a total of 40-50 racing athletes on the Kuantan river every year as a commemoration of the great Islamic holidays and the independence of the Republic of Indonesia (Afrison & Masunah, 2021; Febrian & Jumadi, 2022; Firmanyah & Masunah, 2019; Putra, 2019). Pacu Jalur which has become one of the most well-known cultures in Riau and Indonesia is considered to have the potential to be appointed as material for integration with education, because it is considered to have become one of the proud icons of Kuantan Malay cultural hegemony. Pacu Jalur is also a culture that is included in the national tourism calendar every year and always attracts a lot of interest from the people of Riau, national and foreign tourists (Aslati & Silawati, 2017; Febra et al., 2018; Febrian & Jumadi, 2022; Mahardi & Erlisnawati, 2019; Venydhea & Rosaliza, 2020).

Curriculum Analysis

After getting an overview of the product development, the Pacu Jalur culture-based science textbook, the researcher will proceed to the next analysis stage, to analyze the curriculum, especially on the aspects of core, basic, and standart competency. This analysis aims to see what competency outcomes must be possessed by students in learning science. These results will be considered as book reference for product later. Thus, the product developed is expected to be able to facilitate and support student achievements that have been determined by the curriculum.

Based on the analysis that has been carried out, 3 basic competencies were obtained in the revised 2013 curriculum which have the potential to be integrated with the cultural content of spur lanes. These three basic competencies are in class VIII. The 3 basic competencies can be seen in Table 5.

Table 5. Class VIII Competencies Based on Pathway Culture

3.2 Analyzing straight motion, the effect of force on motion based on Newton's Laws, and its application to the motion of objects and living things.	4.2 Presents the results of the investigation of the effect of force on the motion of objects.
3.3 Explain the concept of work, simple machines, and their application in everyday life including the work of muscles in the human skeletal structure.	4.3 Presenting the results of investigations or solving problems about the benefits of using simple machines in everyday life.
3.8 Explain the pressure of matter and its applications in everyday life, including blood pressure, osmosis, and capillary transport tissue in plants.	4.8 Presenting experimental data to investigate liquid pressure at a certain depth, buoyancy, and capillarity, for example in plant stems.

In supporting product development time efficiency, only basic competencies 3.3 and 4.3 were selected to be developed into book products. This is also based on considering the basic competencies that are most dominantly contained in the cultural content of Pacu Jalur. These basic competencies 3.3 and 4.3 will then be derived and specified again into several indicators of competency achievement. This indicator will be a benchmark for the achievement of students' abilities (cognitive, psychomotor, and effective).

Content Analysis

The researcher then analyzed what content is contained in basic competencies 3.3 and 4.3 which can be integrated with the the Pacu Jalur Kuantan Singingi. Content analysis was carried out on the syllabus and several relevant science learning resources, such as several science textbooks that have been used at school. The results of this analysis are presented in the form of a matrix which will serve as a framework for the development of contents in the book product. The contents analysis matrix can be seen in Table 6.

Table 6. Matrix of Subject

Subject	Physics	Biology	Chemistry	Geology & Astronomy	Health & Safety	Environment	Technology
Work and simple machine in life.	Work Energy Power Simple Machine	Source of energy for humans The principle of a simple machine in a motion system	Chemical energy	-	Safety of Pacu Jalur	-	Tools that apply the principle of a simple machine in Pacu Jalur
Integrated Model	Webbed (Fogarty, 1991)						

This ethnoscience-based science book based on Pacu Jalur culture will be developed using the Webbed (Fogarty, 1991). The book will be packaged into several learning themes and sub-themes. Each theme and sub-theme will be presented in an integrated manner among the loaded science sub-disciplines. Contents on work and simple machines will be discussed and also be presented with various elements perspectives of Pacu Jalur and Malay Kuantan Singingi. It is expected to be able to enriches students insight, improve their achievement, and learning motivation (Hanum et al., 2023; Zinyeka et al., 2016).

Conclusion

Through the analysis of the front end and students conducted, the researchers found that science learning is currently experiencing several problems. Some of these problems include the lack of innovative learning that are contextual and relevant to students, science learning is still taught in a fragmented, and low scientific literacy and a cultural concern. These findings open up opportunities to integrate elements of local wisdom with science learning. Through curriculum and material analysis, researchers found that the cultural content of Pacu Jalur could potentially be loaded as science learning content and resources. Based on the results of this analysis, it can be recommended to develop an ethnoscience-based integrated science book based on the Pacu Jalur Kuantan Singingi. The development of this textbook is expected to be able to increase scientific literacy and cultural concernof students which are considered to be very low, or other science learning problems, especially in Kuantan Singingi Regency.

References

Afrison, J., & Masunah, J. 2021. Social values in jalur dance. *Proceedings of the 3rd International Conference on Arts and Design Education (ICADE 2020)*, 519:227–231. https://doi.org/10.2991/assehr.k.210203.048.

Amrullah, A.R., Suryanti, S., & Suprapto, N. 2021. The development of kinemaster animation video as a media to improve science literacy in elementary schools. *Pendipa: Journal of Science Education*, 6(1):151–161. https://doi.org/10.33369/pendipa.6.1.151-161

Anderhag, P., Wickman, P.O., Bergqvist, K., Jakobson, B., Hamza, K.M., & Säljö, R. 2016. Why do secondary school students lose their interest in science? or does it never emerge? a possible and overlooked explanation. *Science Education*, 100(5):791–813. https://doi.org/10.1002/sce.21231

Ardianti, S.D., Wanabuliandari, S., Saptono, S., & Alimah, S. 2019. A needs assessment of edutainment module with ethnoscience approach oriented to the love of the country. *Jurnal Pendidikan IPA Indonesia*, 8(2):153–161. https://doi.org/10.15294/jpii.v8i2.13285

Aslati, A. & Silawati, S. 2017. Fenomena magis pada tradisi Pacu Jalur di Kabupaten Kuantan Singingi. *Jurnal An-Nida'*, 41(2):101–114. http://dx.doi.org/10.24014/an-nida.v41i2.4647

Asrizal, A., Amran, A., Ananda, A., & Festiyed, F. 2018. Effectiveness of adaptive contextual learning model of integrated science by integrating digital age literacy on grade viii students. *IOP Conference Series: Materials Science and Engineering*, 335(1):1-8. https://doi.org/10.1088/1757-899X/335/1/012067

Asrizal, A., Amran, A., Ananda, A., Festiyed, F., & Khairani, S. 2018. Effectiveness of integrated science instructional material on pressure in daily life theme to improve digital age literacy of students. *Journal of Physics: Conference Series*, 1006(1):1-9. https://doi.org/10.1088/1742-6596/1006/1/012031

Asrizal, A., Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. 2018. The development of integrated science instructional materials to improve students' digital literacy in scientific approach. *Jurnal Pendidikan IPA Indonesia*, 7(4):442–450. https://doi.org/10.15294/jpii.v7i4.13613

Asrizal, A., Festiyed, F., & Sumarmin, R. 2017. Analisis kebutuhan pengembangan bahan ajar IPA terpadu bermuatan literasi era digital untuk pembelajaran siswa SMP kelas VIII. *Jurnal Eksakta Pendidikan (JEP)*, 1(1):1-8. https://doi.org/10.24036/jep/vol1-iss1/27

Atmojo, S.E., Rusilowati, A., Dwiningrum, S.I.A., & Skotnicka, M. 2018. The reconstruction of disaster knowledge through thematic learning of science, environment, technology, and society integrated with local wisdom. *Jurnal Pendidikan IPA Indonesia*, 7(2):204–213. https://doi.org/10.15294/jpii.v7i2.14273

Auerbach, A.J. & Schussler, E.E. 2017. Curriculum alignment with vision and change improves student scientific literacy. *CBE Life Sciences Education*, 16(2):1–9. https://doi.org/10.1187/cbe.16-04-0160

Bröder, J., Okan, O., Bauer, U., Bruland, D., Schlupp, S., Bollweg, T.M., Saboga-Nunes, L., Bond, E., Sørensen, K., Bitzer, E.M., Jordan, S., Domanska, O., Firnges, C., Carvalho, G.S., Bittlingmayer, U.H., Levin-Zamir, D., Pelikan, J., Sahrai, D., Lenz, A., … Pinheiro, P. 2017. Health literacy in childhood and youth: a systematic review of definitions and models. *BMC Public Health*, 17(1):1–26. https://doi.org/10.1186/s12889-017-4267-y

Budiarti, I.S. & Tanta, T. 2021. Analysis on students' scientific literacy of newton's law and motion system in living things. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(1):36–51. https://doi.org/10.24815/jpsi.v9i1.18470

Childs, P.E., Hayes, S., & Dwyer, A. 2015. *Chemistry and everyday life: relating secondary school chemistry to the current and future lives of students. In I. Eilks & A. Hofstein (eds) Relevant Chemistry Education*. Rotterdam: SensePublishers.

Dewi, I.P.M., Suryadarma, I.G.P., Wilujeng, I., & Wahyuningsih, S. 2017. The effect of science learning integrated with local potential of wood carving and pottery towards the junior high school students' critical thinking skills. *Jurnal Pendidikan IPA Indonesia*, 6(1):103–109. https://doi.org/10.15294/jpii.v6i1.9598

Dwianto, A., Wilujeng, I., Prasetyo, Z.K., & Suryadarma, I.G.P. 2017. The development of science domain based learning tool which is integrated with local wisdom to improve science process skill and scientific attitude. *Jurnal Pendidikan IPA Indonesia*, 6(1):23–31. https://doi.org/10.15294/jpii.v6i1.7205

Eufrasia, J., Emilianus, J., Hildegardis, M., & Utami, Y.E. 2019. Penanaman sikap peduli lingkungan dan tanggung jawab melalui pembelajaran IPA pada siswa SMP. *Journal of Komodo Science Education*, *September*, 1(20):24-33. https://jurnal.unikastpaulus.ac.id/index.php/jkse

Fauziyah, A., Prasetyaningsih, P., & Biru, L.T. 2021. Analysis of scientific literacy skills in solving question science on food security themes in serang city. *Jurnal Penelitian Pendidikan IPA*, 6(2):56–63. https://doi.org/10.26740/jppipa.v6n2.p56-63

Febra, A., Sugiyanto, S., & Kristiyanto, A. 2018. Cultural and traditional sport Pacu Jalur location in Regency of Kuantan Singingi Riau Province. *International Journal of Multicultural and Multireligious Understanding*, 5(4):278–287. https://doi.org/10.18415/ijmmu.v5i4.293

Febrian, A. & Jumadi, J. 2022. Identification of science concepts and principles based on local wisdom of Pacu Jalur to develop science learning materials. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(2):355–379. https://doi.org/10.24815/jpsi.v10i2.24011

Firmanyah, A. & Masunah, J. 2019. Jalur dance in the opening ceremony of Pacu Jalur festival in Kuantan Singingi Regency of Riau Province, Indonesia. *1st International Conference on Arts and Design Education (ICADE 2018)*, 255: 81–84. https://doi.org/10.2991/icade-18.2019.18

Fogarty, R. 1991. *How to Integrate to Curricula* (Sixth Edit). Illinois: IRI/Skylight Publishing Inc.

Gusnedi, G., Ratnawulan, R., & Triana, L. 2018. Application of Student book based on integrated learning model of networked type with heart electrical activity theme for junior high school. *IOP Conference Series: Materials Science and Engineering*, 335(1):1-4. https://doi.org/10.1088/1757-899X/335/1/012132

Handayani, R.D., Wilujeng, I., & Prasetyo, Z.K. 2018a. Elaborating indigenous knowledge in the science curriculum for the cultural sustainability. *Journal of Teacher Education for Sustainability*, 20(2):74–88. https://doi.org/10.2478/jtes-2018-0016

Handayani, R.D., Wilujeng, I., & Prasetyo, Z.K. 2018b. Elaborating indigenous science in the science curriculum. *The International Journal of Learner Diversity and Identities*. 25(3–4):22–33. https://doi.org/10.18848/2327-0128/CGP/v25i02/21-34

Handayani, R.D., Wilujeng, I., Prasetyo, Z.K., & Triyanto. 2019. Building an indigenous learning community through lesson study: challenges of secondary school science teachers. *International Journal of Science Education*, 41(3):281–296. https://doi.org/10.1080/09500693.2018.1548789

Hanum, L., Hasan, M., Ulfa, A., Pada, T., Rahmatan, H., Fazlia, R., & Rahmayani, I. 2023. Development of learning devices based on ethnoscience project based learning to improve student's critical thinking skills. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):288–305. https://doi.org/10.

24815/jpsi.v11i2.28294

Hikmawati, H., Suastra, I.W., Suma, K., Sudiatmika, A.A.I.A.R., & Rohani, R. 2021. Effect of problem-based learning integrated local wisdom on student hots and scientific attitude. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue):233–239. https://doi.org/10.29303/jppipa.v7ispecialissue.1118

Huaman, S., & Elizabeth, E. 2016. Tuki Ayllpanchik (our beautiful land): indigenous ecology and farming in the Peruvian highlands. *Cultural Studies of Science Education*, 11(4):1135–1153. https://doi.org/10.1007/s11422-014-9622-z

Ideland, M. 2018. Science, coloniality, and “the great rationality divide". *Science Education*, 27(7-8): 783–803. https://doi.org/10.1007/s11191-018-0006-8

Irmania, E., Trisiana, A., & Salsabila, C. 2021. Upaya mengatasi pengaruh negatif budaya asing terhadap generasi muda di Indonesia. *Dinamika Sosial Budaya*, 23(1):148–160. http://dx.doi.org/10.26623/jdsb.v23i1.2970

Jeleelah, B., Agbetioluwayemisi, A., & Theresa, U. 2016. Instructional material: level of use in teaching and learning of economics in secondary schools. mainland education district IV, Lagos State Nigeria. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, 6(4):107–112. https://doi.org/10.9790/7388-060404107112

Jufrida, J., Basuki, F.R., Kurniawan, W., Pangestu, M.D., & Fitaloka, O. 2019. Scientific literacy and science learning achievement at junior high school. *International Journal of Evaluation and Research in Education*, 8(4):630–636. https://doi.org/10.11591/ijere.v8i4.20312

Kade, A., Syarif, M., & Syukur, S.A. 2019. Pengaruh model blended learning terhadap literasi sains dan hasil belajar. *Jurnal Pendidikan Fisika Tadulako Online*, 7(3):51–55. http://jurnal.untad.ac.id/jurnal/index.php/EPFT/article/view/14586/10915

Kähler, J., Hahn, I., & Köller, O. 2020. The development of early scientific literacy gaps in kindergarten children. *International Journal of Science Education*, 42(12):1988–2007. https://doi.org/10.1080/09500693.2020.1808908

Kemendikbud. 2019. *Hasil PISA Indonesia Tahun 2018*.

Khaddour, R., Al-Amoush, S., & Eilks, I. 2017. The curriculum emphasis in grade-10 chemistry textbooks from seven cross regional Arab countries. *Chemistry Education Research and Practice*, 18(2):375–385. Retrived from https://eric.ed.gov/?id=EJ1137038

Lestariningsih, N., Nirmalasari, R., & Qamariah, Z. 2021. The development of an integrative botanical textbook based on islamic values and medicinal herbs studies of Central Kalimantan. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, 3(2):78-84. https://doi.org/10.20527/bino.v3i2.10598

Mahardi, H. & Erlisnawati, E. 2019. Nilai karakter dalam budaya Pacu Jalur pada masyarakat Teluk Kuantan Provinsi Riau. *Jurnal Ilmiah Pendidikan Guru SD*, 1(1):49–66. https://doi.org/10.31326/jipgsd.v1i1.280

Matsun, Anggraeni, L., & Trisianawati, E. 2019. Pengembangan buku ajar IPA terpadu SMP berbasis eksperimen. *Lectura: Jurnal Pendidikan,* 10(2):107–122. https://doi.org/10.31849/lectura.v10i2.3149

Mubita, S.L., & Kalimaposo, K. 2016. Factors affecting teaching and learning of home economics in the integrated primary curriculum: a study of selected primary schools in Lusaka Province of Zambia. *International Journal of Multidisciplinary Research and Development*, 3(11):9–16. Retrieved from https://www.allsubjectjournal.com/archives/2016/vol3/issue11/3-10-65

Mulyeni, T., Jamaris, M., & Suprjyati, Y. 2019. Improving basic science process skills through inquiry-based approach in learning science for early elementary students. *Journal of Turkish Science Education*, 16(2):187–201. https://doi.org/10.12973/tused.10274a

Novitasari, L., Agustina, P.A., Sukesti, R., Nazri, M.F., & Handhika, J. 2017. Fisika, etnosains, dan kearifan lokal dalam pembelajaran sains. *Seminar Nasional Pendidikan Fisika III 2017*. 81–88. Retrieved from http://e-journal.unipma.ac.id/index.php/snpf/article/view/1617

OECD. 2019. *Indonesia - Country Note - PISA 2018 Results. PISA team Directorate for Education and Skills*.

Olayinka, A.R.B. 2016. Effects of instructional materials on secondary schools students' academic achievement in social studies in Ekiti State, Nigeria. *World Journal of Education*, 6(1):32–39. https://doi.org/10.5430/wje.v6n1p32

Østergaard, E. 2017. Earth at rest–aesthetic experience and students' grounding in science education. *Science & Education*, 26(5):557–582. https://doi.org/10.1007/s11191-017-9906-2

Parmiti, D.P., Rediani, N.N., Antara, I.G.W.S., & Jayadiningrat, M.G. 2021. The effectiveness of local culture-integrated science learning through project-based assessment on scientific attitudes and science process skills of elementary school students. *Jurnal Pendidikan IPA Indonesia*, 10(3):439–446. https://doi.org/10.15294/JPII.V10I3.31301

Permendikbud Nomor 104 Tahun 2014. Kementrian Pendidikan dan Kebudayaan. Jakarta.

Permendikbud Nomor 8 Tahun 2016 tentang Buku yang digunakan oleh satuan pendidikan.

Prest, A., Goble, J.S., Vazquez-Cordoba, H., & Tuinstra, B. 2021. Enacting curriculum in a good way: Indigenous knowledge, pedagogy, and worldviews in British Columbia music education classes. *Journal of Curriculum Studies*, 53(5):711–728. https://doi.org/10.1080/00220272.2021.1890836

Purwanti, D. 2017. Pendidikan karakter peduli lingkungan dan implementasinya. *Dwija Cendekia: Jurnal Riset Pedagogik*, 1(2):14–20. https://doi.org/10.20961/jdc.v1i2.17622

Putra, E.S.I. 2019. Tradisi al di Kabupaten Kuantan Singingi). *Journal Olahraga Indragiri (JOI)*, 4(1):27–56. Retrieved from https://ejournal-fkip.unisi.ac.id/joi/article/view/520

Rahmiwati, S., Ratnawulan, & Yohandri, Y. 2018. The implementation of integrated natural science textbook of junior high school be charged on character-based shared models to improve the competence of learners' knowledge. *IOP Conference Series: Materials Science and Engineering*, 335(1):1-7. https://doi.org/10.1088/1757-899X/335/1/012076

Rinto, R., Hayati, N., Wiyanto, & Ridho, S. 2020. Content validity analysis of ethnoscience-based interview worksheets in bukit ajimut for medicinal plants pharmacognosy learning. *Journal of Physics: Conference Series*, 1567(2):1-4. https://doi.org/10.1088/1742-6596/1567/2/022061

Rohmaan, M. & Mukhibat. 2017. Internalisasi Nilai-nilai sosio-kultural berbasis etno-religi di MAN Yogyakarta III. *Edukasia: Jurnal Penelitian Pendidikan Islam*, 12(1):31–56. http://dx.doi.org/10.21043/edukasia.v12i1.1771

Rostikawati, D.A., & Permanasari, A. 2016. Rekonstruksi bahan ajar dengan konteks socio-scientific issues pada materi zat aditif makanan untuk meningkatkan literasi sains siswa. *Jurnal Inovasi Pendidikan IPA*, 2(2):156-164. https://doi.org/10.21831/jipi.v2i2.8814

Rumalolas, N., Sandra, M., Rosely, Y., & Nunaki, J.H. 2021. The inquiry-based student book integrated with local resources: the impact on student science process skill. *Journal of Research in Instructional*, 1(2):133–146. https://doi.org/10.30862/jri.v1i2.17

Saad, K.M. 2017. Effects of instructional materials on cognitive achievement of secondary schools students in economics in Gombe State, Nigeria. *Journal of Science, Technology and Education*, 5(2):19-26. Retrieved from http://www.atbuftejoste.com/index.php/joste/article/view/362

Sarmi, R.S., Ratnawulan, & Gusnedi. 2019. Learning media analysis in the development of integrated science teacher book with theme the energy in the life using type integrated of 21st century learning. *Journal of Physics: Conference Series*, 1185(1):1-9. https://doi.org/10.1088/1742-6596/1185/1/012080

Savitri, E.N., Amalia, A.V., Prabowo, S.A., Rahmadani, O.E.P., & Kholidah, A. 2021. The effectiveness of real science mask with qr code on students' problem-solving skills and scientific literacy. *Jurnal Pendidikan IPA Indonesia*, 10(2):209–219. https://doi.org/10.15294/jpii.v10i2.29918

Setiawan, B., Innatesari, D.K., Sabtiawan, W.B., & Sudarmin, S. 2017. The development of local wisdom-based natural science module to improve science literation of students. *Jurnal Pendidikan IPA Indonesia*, 6(1):49–54. https://doi.org/10.15294/jpii.v6i1.9595

Siswanto, J., Mahtari, S., Febriani, W., & Sari, E. 2023. *The Barriers to Developing Students' Scientific Literacy in Learning Physics of Quantities and Measurements*. 11(2):206–220. https://doi.org/10.24815/jpsi.v11i2.27767

Soo-bum, L. & Sei-Hill, K. 2018. Scientific knowledge and attitudes toward science in south korea: does knowledge lead to favorable attitudes?. *Science Communication*, 40(2):147–172. https://doi.org/10.1177/1075547017753189

Sukmawati, W. 2017. Pembelajaran kontekstual dengan saintifik inkuiri untuk meningkatkan literasi dan sikap sains siswa. *Bioeduscience*, 1(1):31-37. https://doi.org/10.29405/bioeduscience/31-37111085

Sukowati, D. & Rusilowati, A. 2017. Analisis kemampuan literasi sains dan metakogntif peserta didik. *Physics Communication*, 1(1):16–22. https://doi.org/10.15294/physcomm.v1i1.8961

Suprianti, D., Munzil, M., Hadi, S., & Dasna, I.W. 2021. Guided inquiry model assisted with interactive multimedia influences science literacy and science learning outcomes. *Jurnal Ilmiah Sekolah Dasar*, 5(3):415-424. https://doi.org/10.23887/jisd.v5i3.38802

Tabi'in, A. 2017. Menumbuhkan sikap peduli pada anak melalui interaksi kegiatan sosial. *Ijtimaiya: Journal of Social Science Teaching*, 1(1):39-59. https://doi.org/10.21043/ji.v1i1.3100

Ulandari, L., Amry, Z., & Saragih, S. 2019. Development of learning materials based on realistic mathematics education approach to improve students' mathematical problem solving ability and self-efficacy. *International Electronic Journal of Mathematics Education*, 14(2):375–383. https://doi.org/10.29333/iejme/5721

Venydhea, A. & Rosaliza, M. 2020. Dukun jalur desa Saik Kuantan. *Jurnal Ilmu Budaya*, 16(2):120–139. https://doi.org/10.31849/jib.v16i2.3708

Vieira, R.M., & Tenreiro-Vieira, C. 2016. Fostering scientific literacy and critical thinking in elementary science education. *International Journal of Science and Mathematics Education*, 14(4):659–680. https://doi.org/10.1007/s10763-014-9605-2

Widiyatmoko, W. & Wiyanto, A. 2016. Preparation model of student teacher candidate in developing integrative science learning. *Journal of Education and Human Development*, 5(2):169–177. https://doi.org/10.15640/jehd.v5n2a20

Wilujeng, I. 2016. Pengintegrasian Potensi lokal dalam pembelajaran ipa alternatif peningkatan daya saing global. *Prosiding Seminar Nasional IPA VII*, 680–688.

Wilujeng, I. 2019. *IPA Terintegrasi dan Pembelajarannya* (M. Hasan (ed.); 1st ed.). Yogyakarta: UNY Press.

Yenni, R., Hernani, & Widodo, A. 2017. The implementation of integrated science teaching materials based socio-scientific issues to improve students scientific literacy for environmental pollution theme. *AIP Conference Proceedings*, 1848:1-*4*. https://doi.org/10.1063/1.4983970

Yusnitasari, A. & Isnaeni, W. 2019. Concept mastery of ethnoscience-based integrated science and life skills development of elementary school students. *Journal of Primary Education*, 8(4):93–101. https://doi.org/10.15294/jpe.v9i1.29111

Zidny, R., Sjöström, J., & Eilks, I. 2020. A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science and Education*, 29(1):145–185. https://doi.org/10.1007/s11191-019-00100-x

Zidny, R., Solfarina, S., Aisyah, R.S.S., & Eilks, I. 2021. Exploring indigenous science to identify contents and contexts for science learning in order to promote education for sustainable development. *Education Sciences*, 11(3):1-14. https://doi.org/10.3390/educsci11030114

Zinyeka, G., Onwu, G.O.M., & Braun, M. 2016. A truth-based epistemological framework for supporting teachers in integrating indigenous knowledge into science teaching. *African Journal of Research in Mathematics, Science and Technology Education*, 20(3):256–266. https://doi.org/10.1080/18117295.2016.1239963

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Development of Android Based Educational Games as Learning Media on the Concept of Coordination System for Grade XI High School Students

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Abstract. Many students spend time with their smartphones for entertainment, one of which is playing games, and rarely use their smartphones for learning media. This study aims to develop educational game applications, and determine the feasibility and responses of teachers and students to android based educational game applications on the concept of a coordination system. This study uses a developmental research method with a 4D development model consisting of four stages: define, design, develop, and disseminate. The sampling technique is by purposive sampling. The data collection uses a closed questionnaire. Questionnaires are used to assess the feasibility of media by media experts, material experts, teachers and students. Analysis of the data obtained is carried out by quantitative descriptive. In the define stage, the results were obtained from interviews with biology teachers and the distribution of media needs questionnaires to students. In the design stage, the results of the media design (prototype) are obtained. In the develop stage, the results of the media expert validation were 90.67% (very good), while the material expert validation results were 81.25% (very good). Furthermore, a trial was conducted on the teacher and 35 students of class XII high school. The results of the assessment for teachers are 96.88% (very good) and for students are 87.57%. In the disseminate stage, the teacher's response was 98.75% (very good) and the student's response was 83.42% (very good). It is concluded that the educational game-based android application is appropriate to be used as a media for learning biology.
Keywords: Educational Game, Learning Media, Coordination System

Introduction

Currently, technological developments occur very rapidly. These developments have resulted in various types of products ranging from the internet, computers, laptops, to smartphones which are widely used in various aspects of life. In particular, smartphones are devices that have the most number of users. The number of smartphone users in Indonesia continues to increase from 11.7 million in 2011 to 62.69 million in 2017. The number of users is predicted to reach 89.86 million in 2022 (Machmud, 2018). Students spend more than 6 hours per day using their smartphones. However, most students use their smartphones for entertainment such as playing games and social media (Mulyani et al., 2019; Cha & Seo, 2018). In addition, students also doubt that they can learn effectively through smartphones, because these objects are a source of distraction, stress, and a waste of time (Rahaman, et al., 2020; Iqbal & Bhatti, 2020). This is similar to the interview conducted at SMAN 11 Kota Tangerang Selatan (SMAN A) on 81 students of class XI MIPA, that as many as 90% of students have an android type smartphone, used the most for social media, browsing, and playing games. There are still a few who use their smartphone as a learning media (Qumillaila et al., 2017).

To achieve effective learning, teachers need to use good learning media. There have been many studies that explain that the media can affect student learning achievement. There are four reasons for the importance of using learning media, namely (1) improving the quality of learning, (2) demands a new paradigm, (3) market needs, and (4) global education vision (Yaumi, 2018). Knowing the importance of learning media, teachers should be able to consider the right type of learning media used to achieve learning objectives, because not all digital media can be accepted and work effectively to become learning media (Febrianto et al., 2020).

If a teacher has skills regarding media and technology, then the teacher can easily manage a constructivist learning environment which also requires the ability to help students construct information for their learning (Anagün, 2018). Therefore, teachers need to have skills regarding the use or even manufacture of learning media so that students more easily digest the learning information provided. The teacher also needs to choose the type of media that will be made so that it can be adapted to the characteristics of the students and the material that will be provided so that learning outcomes can be maximized (Widodo & Wahyudin, 2018). There are many types of media that teachers can choose from, such as audio, visual, and audiovisual media. There are even multimedia which is a combination of many media, especially those that use technology (Prasasti et al., 2018). The teacher must be prepared with the type of media chosen for learning, but the teacher's readiness to use learning media is also influenced by the ability of students to use the media. When the teacher is ready to use learning media but the students have not been able to keep up with these developments, in the end, the learning process will run less than optimally (Churiyah et al., 2020).

The type of learning media most often used by teachers in delivering material is powerpoint (Cahyana et al., 2019). This is because it is easy to make powerpoint media, many features can be used such as to insert text, images, video, sound, transition from one slide to the next, add text color, and provide graphics and diagrams (Mudasih & Subroto, 2019). However, in practice, powerpoint requires other tools such as projectors to be displayed. Not all schools have supporting facilities and infrastructure. In addition, the use of powerpoint media will make students only listen to explanations from the teacher, students are not actively involved in learning (Cahyana et al., 2019). If learning continues like that, students will become bored, which results in students stealing time to open their smartphones when the teacher explains the material in power point. Therefore, teachers need to innovate in making learning media that can attract the interest and attention of students in learning so as not to get bored quickly (Zulfiani et al., 2021).

One of the learning media innovations that can be developed by teachers is games. Currently, the game is still seen as something negative. Games are always associated with less useful activities and just a waste of time, this is because many children ask for more time to play games, so it will be increasingly difficult to control their children because they are addicted and make them lazy to learn (Ritonga et al., 2021). Many parents forbid their children to play games. However, there are types of games that combine the experience of playing games and learning material or often referred to as educational games. Educational games are digital games designed for educational enrichment (supporting teaching and learning) (Adrian & Apriyanti, 2019). Educational games contain learning material content that aims to improve the learning abilities of its users towards a material (Wibawanto, 2020). Educational games have the goal of cultivating student interest in learning material, if the learning material contains a game, a feeling of pleasure will appear so that it is hoped that students can more easily understand the subject matter that has been conveyed by the teacher in learning activities. In addition, educational games also have benefits for improving critical thinking skills. Educational games specifically based on Android will be easier to access anywhere and anytime (Kongvitayanont et al., 2017; Mohanty et al., 2021).

Students still view biology as difficult and unpleasant material. There are various factors that cause this, namely (1) the characteristics of biological material that are difficult to visualize or observe directly, are too abstract and use lots of foreign terms. This causes students to think that to learn biology they have to memorize a lot of facts in it, so they will find it difficult to learn biology. Even teachers sometimes avoid teaching some aspects of the subject of biology because of its abstractness (Akinbadewa & Sofowora, 2020). (2) The teacher's teaching style is still teacher-centered. Many teachers only transfer knowledge from books, without any student-centered activities. Of course, this can cause negative effects on attitudes and motivation to learn. (3) The learning habits of students who rarely repeat to study biology material that has been delivered by the teacher. This is the impact of the teacher's teaching style which is less pleasant so students are not interested in what is taught in class. (4) Lack of facilities and learning time. Not all schools have facilities and infrastructure that support biology learning, such as inadequate biology laboratories, lack of projectors, etc. In addition, the limited learning time to teach all biology material makes teachers rarely provide student-centered activities/projects (Cimer, 2012).

One of the biology topics that are difficult for students to understand is the coordination system material. This is because there are too many concepts that need to be studied on the topic of coordination systems (Fauzi & Mitalistiani, 2018). In the topic of coordination system, there are 3 main concepts, namely the nervous system, sensory system, and endocrine system. These three concepts are complex physiological material. Students' initial understanding that is still lacking regarding physiological concepts makes it increasingly difficult for them to understand them (Zahora & Saparso, 2021). The nervous system in humans is a learning concept that contains some abstract material and cannot be observed directly by students. Students find it difficult to learn this material if they only use print media. For example the mechanism of the passage of nerve impulses to send messages to the central nervous system. This material requires simplification using media that can visualize it to help students understand concepts. In addition, students also find it difficult to understand the composition of the human nervous system (Hafzah et al., 2020). This is in following the results of interviews with biology teachers at SMAN A Kota Tangerang Selatan which stated that coordination system biology material was difficult material to convey. When the teacher conveys the coordination system material, many students complain that it is difficult to understand the material because there are many foreign terms, as well as many functions and structures that need to be memorized. As much as 53% of students also agreed that the coordination system material was difficult.

As previously explained that there are many benefits from using games in learning, so it is hoped that educational games can be a solution to the problem of students' difficult understanding of the topic of coordination systems. This study aims to develop educational games as alternative learning media that can be used in biology lessons, as well as to see the feasibility and response of students and biology teachers to the media developed.

Methods

The type of research used is developmental research with the 4D model (Four-D Models) by Thiagarajan (1974). The model has four stages of development, namely define, design, develop, and disseminate. The define stage is an activity to determine needs through analysis of teachers, students, minimum competencies, learning concepts, and formulation of learning objectives. The design stage consists of preparing the model concept framework and tools to produce prototype I. The develop stage is the stage for testing prototype I through expert validity and assessing the feasibility of the media through direct trials on students to produce prototype II. The disseminate stage is implementing the product on the real target (Muthmainnah et al., 2022).

The define stage in this study was carried out by interviewing biology teachers and distributing media needs questionnaires to students in class XI MIPA at SMAN A Kota Tangerang Selatan. The design stage in this study was carried out by making flowcharts, storyboards, and combining materials into products with construct 2 software. Then the product development was validated by 3 media experts from UIN Syarif Hidayatullah Jakarta and 2 material experts with details one person from UIN Syarif Hidayatullah Jakarta and one person from a biology teacher at SMAN A Kota Tangerang Selatan. In addition, a development trial was also carried out on 36 students from class XI MIPA 1 at SMAN A Kota Tangerang Selatan. Furthermore, it was disseminated to the same school with a larger sample of students from the trial, namely 61 students in class 12 MIPA and 1 biology teacher.

The sampling technique is by purposive sampling. This is done by selecting schools that apply the 2013 Curriculum in learning activities and the sample selected for research is class XI students with consideration of cognitive ability based on information from the teacher. The data collection uses a non-test form, namely by giving a closed questionnaire. Questionnaires are used to assess the feasibility of media by media experts, material experts, teachers and students. The questionnaire uses a Likert scale with criteria based on Table 1. Analysis of the data obtained is carried out by quantitive descriptive by dividing the total score obtained by the maximum total score (formula 1) and converted to obtain the appropriate category of feasibility in Table 1.

Table 1. Scoring on a Likert Scale

Score	Criteria
5	Very Good
4	Good
3	Sufficiently Good
2	Not Good
1	Very Not Good

After the score results are obtained, the percentage of media eligibility is calculated using the following formula by Sugiono (2013).

$$\mathrm{P} = \frac{\text{The total score of the overall data collection results}}{\text{Total criterion scores}} \times 100\% \qquad (1)$$

Then conclude the results of calculations based on aspects by matching them to the assessment criteria in Table 2.

Table 2. Media Assessment Scale

Percentage of Media Asessment	Criteria
81 - 100	Very Worthy/Very Good
61 - 80	Worthy/Good
41 - 60	Sufficiently Worthy/Sufficiently Good
21 - 40	Unworthy/Not Good
0 - 20	Very Unworthy/Very Not Good

(Source: Riduwan & Akdon, 2013)

Results and Discussion

The results of this study are described based on the stages of the 4D model, namely define, design, development, and disseminate.

Define

This stage aims to determine and define the requirements needed in learning by analyzing the objectives and limitations of the material in the media to be developed. This stage includes 5 steps, namely: (a) Front-end analysis, (b) Student analysis, (c) Task analysis, (d) Concept analysis, and (e) Formulation of learning objectives (Latifah et al., 2020).

Front-end analysis was carried out by interviewing one of the biology teachers at SMAN A Kota Tangerang Selatan. The results obtained are in the form of problems related to learning, namely (1) PPT (powerpoint) media is often used in classroom learning. However, the limited availability of projector equipment means that the PPT media cannot always be displayed in front of the class so learning becomes less effective; (2) In classroom learning, teachers often ask students to find and observe relevant pictures related to the material being studied through google. However, many students complained about the unstable internet network in the school area, making it difficult to search; (3) The teacher complains that the topic of coordination system is broad and complex due to the amalgamation of the concept of the nervous system, sensory system, and endocrine system, making it difficult to convey it to students. Even when the teacher teaches the material, many students find it difficult to understand because they have to memorize various difficult structures and terms.

Student analysis was carried out by distributing media needs questionnaires to students who were the target of using the developed media. The results obtained from the distribution of the questionnaire, it is known that all students have smartphones and 90% use smartphones of the android type. Many students consider smartphones as important tools and are often used in everyday life. One of the most widely used smartphone facilities by students is to play games. The types of games most played by students were strategy games, adventurous games, and educational games. In terms of the topic of biology, students also agreed with the teacher, as many as 53% of students considered that the coordination system material was difficult and agreed to make it in the form of a game to increase their understanding and interest in learning the material. By making learning game media in the coordination system, it is hoped that students can learn in a fun way and not experience boredom because of the many concepts. Learning media game edukasi science adventure that can help students understand the concept of global warming, and can help students practice their problem-solving skills (Winarni et al., 2019).

Task analysis is carried out to find out the main tasks that students need to master to achieve minimum competence. Based on the front-end analysis and student analysis, it is known that media development needs to be done on the coordination system material. The main task of the coordination system for the cognitive domain refers to the 2013 curriculum on biology topic in class 11 high school at KD 3.10 which reads: "Analyzing the relationship between the structure of the organ-composing network in the coordination system (nerves, hormones, and sensory organs) in relation to coordination mechanisms and the regulation and dysfunction that can occur in the human coordinating system”.

Concept analysis was carried out to determine the content of the material to be included in the developed media. The analysis is carried out by narrowing down important concepts that will be taught to students from the topic of coordination systems. The concepts that will be included in the media are the nervous system (definition of the nervous system, division of the nervous system, structure and function of nerve cells, types of nerve cells, mechanism of action of the nervous system, disorders of the nervous system), endocrine system (understanding of the endocrine system, types of endocrine glands, types of hormones, mechanism of action of the endocrine system, disorders of the endocrine system), and the sensory system (definition of the sensory system, structure and function of the sense organs, mechanism of action of the sensory system, and disorders of the sensory system). After carrying out task analysis and concept analysis, learning objectives can be formulated in the form of competency achievement indicators based on KD 3.10. The formulation of learning objectives is intended to change behavior in the form of understanding learning topics after using the developed media.

Design

The design stage aims to prepare prototype devices such as test preparation, media selection, and format selection. In this stage, the initial design is also determined by making flowcharts and storyboards (Ramdani et al., 2020). To prepare for the test, it is done by designing instruments for data collection that contain indicators that can measure the feasibility of the media being developed. The design of the instrument begins with the creation of an assessment grid for media and material expert validation, as well as a grid for student and teacher response questionnaires. As for the selection of media based on the results of the analysis that was carried out at the define stage, it was decided to choose the media in the form of an android-based educational game. Meanwhile, the presentation format chosen in the development of educational game media is in the form of an application that can be run on an android-type smartphone. The application page display format is horizontally oriented (landscape) so that the application display is orderly and comfortable to look at. In addition, the content format of the application consists of instructions for use, developer information, music settings, material menus, and game menus.

After determining the characteristics of the media and the type of format, a design is made to produce the initial product (prototype). The design stage is carried out by making flowcharts, storyboards, and combining materials to become learning game media products. Below is a flowchart image for the coordination system learning game application:

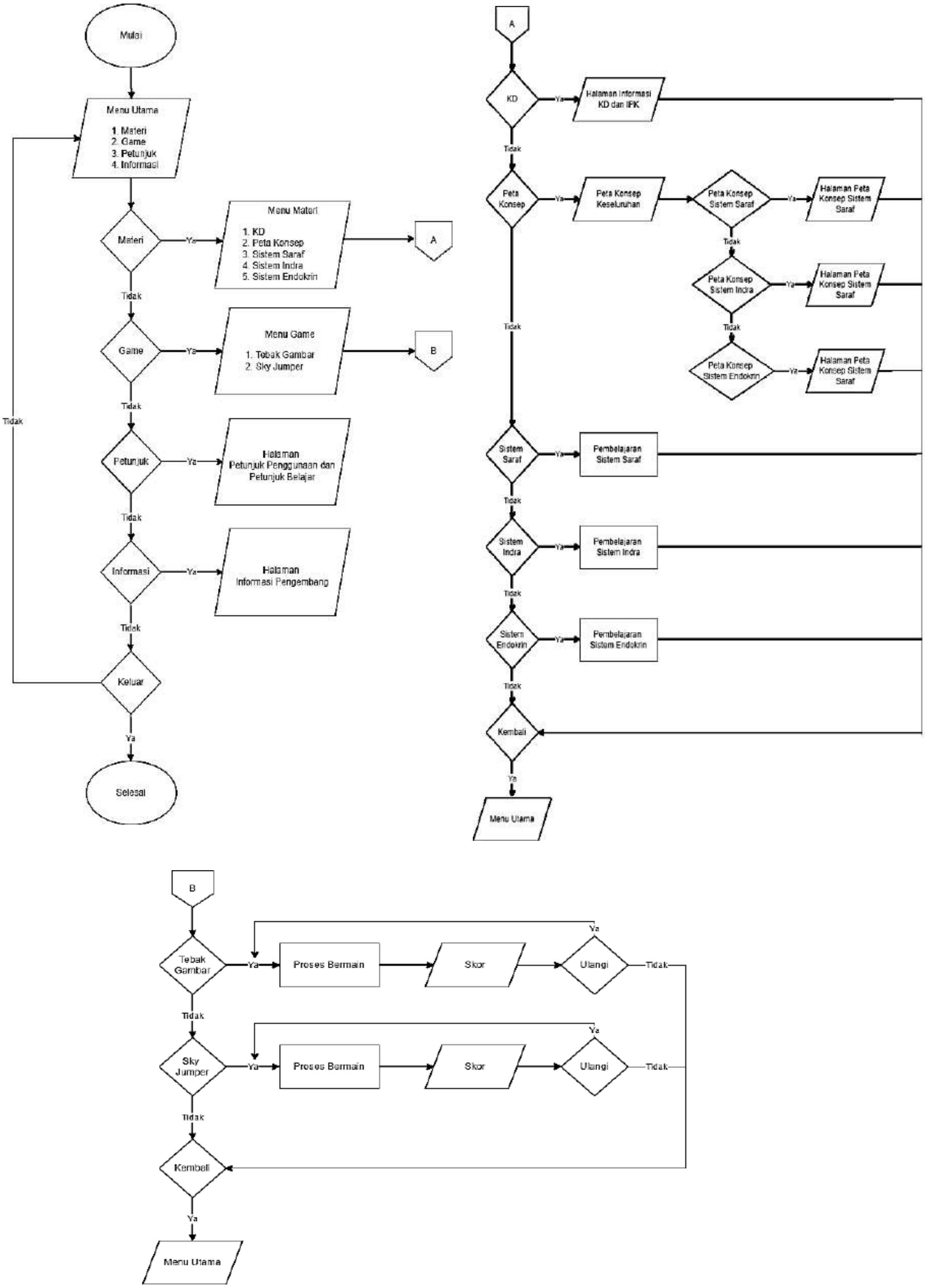
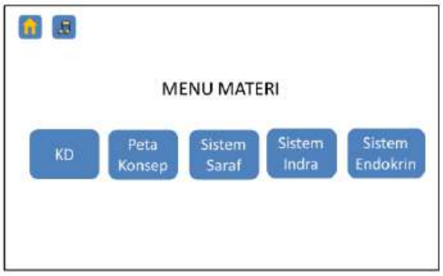
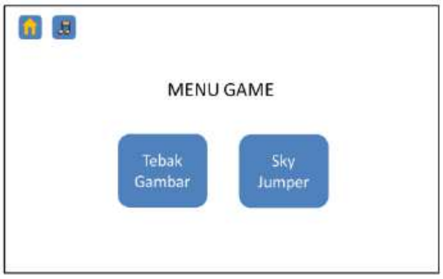


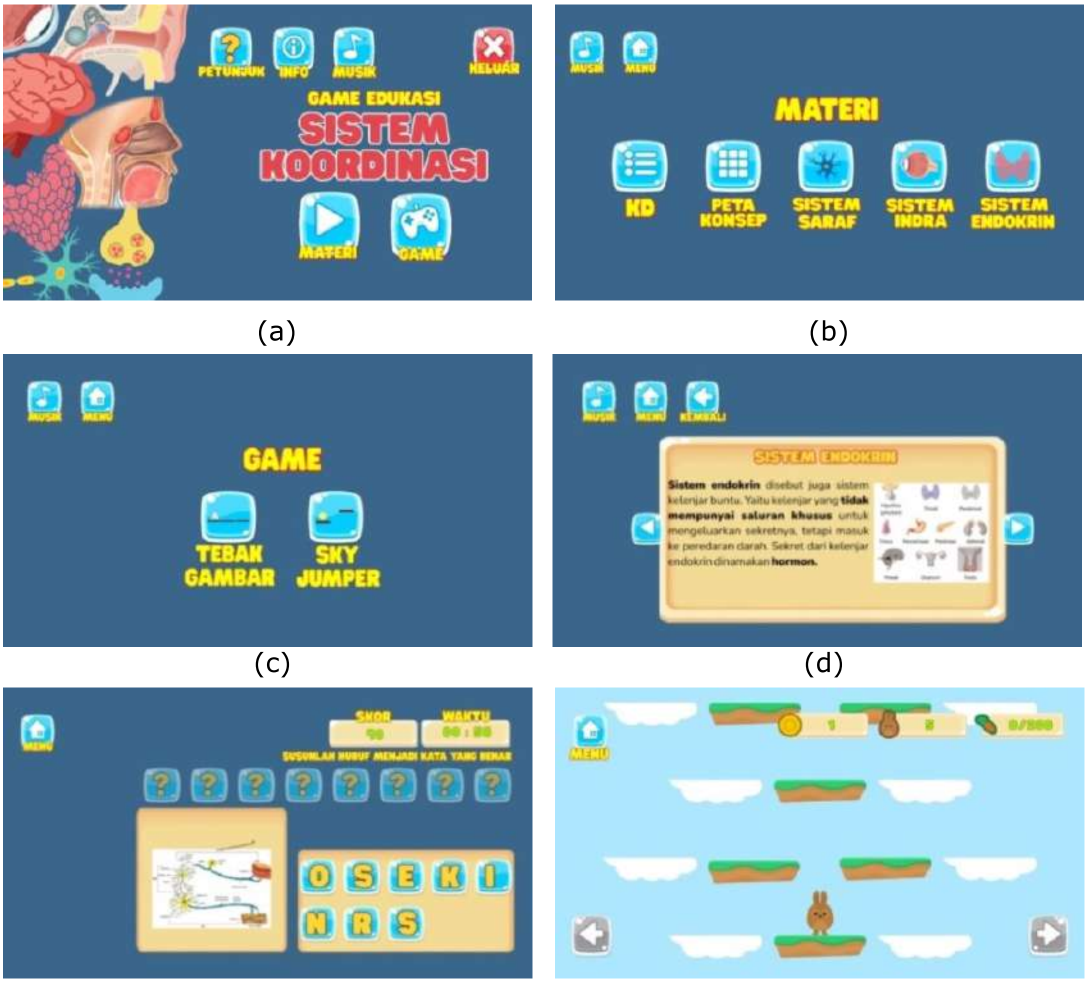
Figure 1. Flowchart Media Educational Game Coordination System

After the flowchart is made, the next step is storyboarding. The storyboard contains a sequence of pictures that will show the idea or outline of the media to be developed. With storyboards, it will make it easier for developers to visualize and realize the interactivity of the learning game application to approach the final appearance (Manggopa et al., 2022).

Table 3. Storyboard

No.	Appearance	Description
1	Main menu Page  	The main menu page consists of materials, games, instructions for use (question mark symbol), developer information (letter i symbol), a music button, and an exit button.
2	Material Menu Page  	The material menu page consists of several buttons to choose from, there is a KD button which contains basic competencies and achievement indicators, a concept map button, and three buttons that contain material on the nervous system, sensory system, and endocrine system, as well as the home button to return to the main menu.
3	Game Menu Page  	On this game's menu page, two types of games can be played, there is *Tebak Gambar* where there are questions in the form of pictures that need to be guessed, and Sky Jumper which has multiple-choice questions.

The next stage is collecting and compiling game assets for making the application. The assets in the form of buttons, letters, characters and other items were obtained by the authors from the websites http://www.gameart2d.com and http://www.kenney.nl. Both of these websites specifically provide game assets to be used free of charge and are free to use for other developers. The merging of material, images, music, and all game assets is done using the construct 2 software. Once finished, the files from construct 2 are exported into an .apk format file with the help of the android studio software. After the process of compiling and combining these materials, a prototype (initial product) can be produced which can be continued for testing at the development stage. Below is a picture of the prototype:



(a) (b) (c) (d) (e) (f)

Figure 2. Results of the Coordination System Educational Game Prototype. (a) main menu, (b) material menu, (c) game menu, (d) material content, (e) *Tebak Gambar* game, (f) Sky Jumper game

Based on Figure 2, the developed media has several main features, namely there is material in the form of text and images, and games in which there are quizzes which can be used as an evaluation of learning outcomes. Learning media in this form can be used both online and offline, so students can also learn remotely by using the game (Aryani, et al., 2023).

Develop

The development stage begins with validating experts and conducting product trials on students. The development of interactive multimedia based on educational games was reported by Panjaitan et.al 2020 which proved valid and feasible as a medium for learning respiratory system material by material experts and media experts. This validation is needed to ensure the suitability of the material and the fulfillment of media criteria in accordance with the specifications of the device (Panjaitan et al., 2020).

The data collected in this validation are quantitative data and qualitative data. Qualitative data were obtained from the results of comments and suggestions from questionnaires which were assessed by material experts and media experts for product validation and the results were used for improvement. Quantitative data was obtained from the results of scoring from a questionnaire in the form of a description of the eligibility presentation by experts and students (Amanda et al., 2020). The first validation is media validation. The results of the assessment of media experts can be seen in Table 4.

Table 4. The Results of The Assessment of Media Experts

No.	Aspect	Percentage	Category
1	Program	90	Very Good
2	Visual	91	Very Good
3	Game elements	91	Very Good
	Average	90,67	Very Good

Based on the table above, it can be seen that the average of all aspects of the assessment by media experts shows that the media is in the very good category. The programming aspect received a very good rating of 90%. This indicates that the evaluation indicators in the programming aspect are in a good category, namely the media is easy to operate and install, the buttons function properly, various menus can be selected, light application memory usage, and clear instructions for use. Likewise, the visual aspect gets a very good rating of 91%. This shows that the various views of the developed media are in a good category, namely attractive application visual design, text and image clarity, layout regularity, and attractive game character appearance. For aspects of game elements, they also get a very good rating, namely 91%. This indicates that the game elements in the developed media are adequate, namely the existence of scores, missions, and challenges that make users more interested and motivated to complete them. Gamification of education can increase the level of student engagement similar to what games can do, to improve their specific skills and optimize their learning (Barata et al., 2013).

The next validation is material validation. The results of the material expert's assessment can be seen in Table 5.

Table 5. The Results of The Assessment of Material Experts

No.	Aspect	Percentage	Category
1	Learning	84	Very Good
2	Presentation	80	Good
3	Language	75	Good
4	Evaluation	86	Very Good
	Average	81,25	Very Good

Based on the table above, it can be seen that the average assessment results of material experts get a score of 81.25% or very good category. The learning aspect gets a score of 84% or is in a very good category. This indicates that the learning in the developed media is adequate, namely the material is in accordance with the basic competencies, the material is complete, the material is in accordance with the ability level of students, the learning instructions are clear, the picture information is clear, and the media can be used by students for independent learning. For the presentation aspect, it gets an assessment of 80% or is in a good category. This indicates that the presentation of the material in the developed application is coherent, interesting, and can be read clearly. Meanwhile, the language aspect received an assessment of 75% or was in a good category. This indicates that the use of language in the developed application is good, namely the language used is based on PUEBI, easy to understand, does not cause double meanings, and is consistent in the use of terms. As for the evaluation aspect, it gets an assessment of 86% or is in the very good category which indicates that the evaluation questions in the game media are adequate from the available material and there is feedback in the form of discussion of the questions.

The learning game media prototype that has been validated gets an average rating from media experts of 90.67% and from material experts of 81.25%, so that the entire prototype is declared very feasible and can be continued to the next stage, there is a development trial for participants biology teacher and student. However, before conducting the trial, improvements need to be made in accordance with the comments and suggestions from the validators (Kristanto et al., 2019). The results of the improvements based on the suggestions and comments of the validators can be seen in Table 6.

Table 6. Media Revision Results

Aspect	Before Revision	After Revision
Concept maps	Concept maps are still in a general form.	The general concept map is added with a button that can be pressed to go to the specific concept map for each material.
Numbering on the mechanism	The chart on the mechanism for transmitting impulses through nerve cells still doesn't have numbering, so it's difficult to know the order.	The mechanism already has a coherent numbering of stages.
Mechanism fittings	The working mechanism of the senses is still incomplete, it only stops in the brain.	The working mechanism of the senses is complete, once it reaches the brain it will be translated into the form of a stimulus-response.
Game instructions	Game instructions need to be detailed more fully and provide a back button.	Game instructions are complete and there is a back button.
Picture questions and the layout of the *Tebak Gambar* game	The picture questions in the *Tebak Gambar* game are not big enough and the layout is not neat.	The pictures of the questions have been enlarged and the layout has changed to be neater.

After the prototype has been revised in accordance with the comments and suggestions given by experts, a prototype-II will be produced which needs to be tested again for its feasibility. The test was conducted on 1 biology teacher and 36 students at SMAN A Kota Tangerang Selatan to find out the response to the prototype-II educational game being developed. The results of the teacher's assessment of prototype-II can be seen in Table 7.

Table 7. Assessment Results by The Teacher

No.	Aspect	Percentage	Category
1	Technical	100	Very Good
2	Visual	90	Very Good
3	Learning	97,5	Very Good
4	Benefit	100	Very Good
	Average	96,88	Very Good

Based on the table above, each aspect of the teacher's assessment is already in the very good value category. Technical aspects get an assessment with a percentage of 100%

or very good, which means technical as the application is easy to use, the buttons work properly, and the application has no errors. Likewise, the visual aspect gets a very good rating with a percentage of 90% which indicates that the application display design is attractive, the display of text and images is clear, and the media layout is pleasing to the eye. The learning aspect also received a very good rating with a percentage of 97.5% which indicated that the material presented was appropriate, complete and coherent, as well as questions and discussion of questions that users could use to practice their knowledge. The benefits aspect also received a very good assessment with a percentage of 100%, which means that the application is in accordance with learning needs, can make it easier for teachers to explain learning material, can motivate students, and help students to learn independently. As well as powtoon-based science learning media developed by Bungawati & Rahmadani (2023) is appropriate for use in learning to increase students' learning motivation.

For the assessment carried out on students there are also technical, visual, learning, and benefit aspects. Although the aspects assessed are the same as the teacher's, the points of assessment are different. The results of the assessment of students can be seen in Table 8.

Table 8. Assessment Results by The Students

No.	Aspect	Percentage	Category
1	Technical	87,56	Very Good
2	Visual	85,78	Very Good
3	Learning	88,89	Very Good
4	Benefit	88,06	Very Good
	Average	87,57	Very Good

Based on the table above, it is known that all aspects assessed by students are already in the very good category. The highest score is in the learning aspect, which is 88.89%. This indicates that students easily understand the material in the application, easily understand the language used, can do the questions in the game well, and understand more with the discussion of the questions. The technical aspect also received a very good rating with a percentage of 87.56% which indicated that most students found it easy to run the application, easily select the available menus, and found no errors or errors in the application. As for the visuals, they also received a very good rating with a percentage of 85.78%, which means that most students agree that the appearance of the application is attractive, the music and audio are attractive, and they can clearly read the text in it. For the benefit aspect, it also gets a very good assessment with a percentage of 87.57%, which means that students agree that the application developed can help understand coordination system material, the application can increase interest and motivation in learning, and the application can be used for independent study at any time and anywhere. These results are in line with research that discusses the development of powtoon for learning media, an average yield of 88% is obtained, which means it is feasible to use (Arif & Muthoharoh, 2021).

Based on the assessment responses of biology teachers and students in this development trial, it show that the media is very suitable for use in learning, and it can be continue for dissemination. The media at this stage were not revised because the comments and suggestions given by teachers and students were mostly in the form of positive responses. Revision decisions are, of course, obtained from comments and suggestions that do not indicate suggestions for material or media improvements (Agustini et al., 2021).

Disseminate

Dissemination is the activity of disseminating or promoting a product to find out its effectiveness of the product so that it can be accepted by users (Ariani & Puspasari, 2022). In this study, the dissemination of educational game application products was carried out in the same school to 61 students and 1 biology teacher. Dissemination is only done to assess the feasibility of the media, not to assess its effectiveness. This is due to the constraints of time and cost constraints. Dissemination can also be done by students and teachers through social media because the application is distributed via google drive. The results of the teacher's assessment can be seen in Table 9.

Table 9. Results of Teacher Responses at the Dissemination Stage

No.	Aspect	Percentage	Category
1	Technical	100	Very Good
2	Visual	95	Very Good
3	Learning	100	Very Good
4	Benefit	100	Very Good
	Average	98,75	Very Good

Based on the table above, it is known that the average results of dissemination of teachers to the media are included in the very good category. The scores on the visual and learning aspects have increased compared to the development trials. For the visual aspect, it still gets the lowest score compared to other aspects, but it still consistently gets very good criteria. However, this shows that the visual aspect can still be developed to be even better.

The results of the dissemination response to students, it was carried out in greater numbers than during the development trial. The results of the response questionnaire for each aspect can be seen in Table 10.

Table 10. Results of Students Responses at the Dissemination Stage

No.	Aspect	Percentage	Category
1	Technical	82,95	Very Good
2	Visual	83,6	Very Good
3	Learning	83,11	Very Good
4	Benefit	84,01	Very Good
	Average	83,42	Very Good

Based on the table above, it is known that the average percentage of students' assessments at the dissemination stage decreased compared to the results during the development trials. It is because the number of respondents is greater, so there are more various obstacles from the side of students. One of them is from a technical aspect. It was found that several students tried the application but had to force it to close when playing because the system stopped due to smartphone memory being too full. These obstacles are beyond the control of development, but this shows that the more respondents, the more valid the dissemination results will be (Amalia et al., 2022).

Based on the dissemination results, it is known that although there is a decrease in student assessment, it is still consistently in the excellent category. The average teacher response is 98.75%, and the average student response is 83.42%, so the coordination system educational game media application product is very feasible to use in learning. The TaPe Game App development for elementary school students was reported to Fauzi (2019) that this game prototype is a learning tool, but further development and testing are still needed to perfect this game prototype. The potential of games in learning thus strengthens the urgency and the challenge of developers and educators to obtain practical tools in various subjects that demand visualization, such as in the material of building space, and are easy to use by students (Pramuditya et al., 2019). Visualization positively impacts learning, in line with Mulyana et al. (2023) research results that developing powtoon-based animated video designs attracts students' attention and improves critical thinking skills and high curiosity.

Conclusion

Based on the results of this study, educational game applications on the coordination system concept get an average rating from media experts of 90.67% or a very good category and from material experts is 81.25% or a very good category, so the application media is very feasible to be tested. As for the development test results, it was obtained that the educational game application media received an average rating from the biology teacher of 96.88% or very good category and from students 87.57% or very good category, so the application media is very feasible for dissemination. At the dissemination stage, the average assessment results were obtained from teachers at 98.75% or very good category and from students at 83.42% or very good category. Based on the responses made to the trials and dissemination, the media is very suitable for use in learning.

References

Adrian, Q.J., & Apriyanti, A. 2019. Game edukasi pembelajaran matematika untuk anak SD kelas 1 dan 2 berbasis android. *Jurnal Teknoinfo*, 13(1):51–54. https://doi.org/10.33365/jti.v13i1.159

Agustini, I.N., Sa’adah, S., & Paujiah, E. 2021. Digital comics learning media for high school on the human excretory system concept. *Research and Development in Education*, 1(2):71–85. https://doi.org/10.22219/raden.v1i2.18911

Akinbadewa, B.O. & Sofowora, O.A. 2020. The effectiveness of multimedia instructional learning packages in enhancing secondary school students’ attitudes toward biology. *International Journal on Studies in Education (IJonSE)*, 2(2):119–133.

Amalia, R.N., Dianingati, R.S., & Annisaa’, E. 2022. Pengaruh jumlah responden terhadap hasil uji validitas dan reliabilitas kuesioner pengetahuan dan perilaku swamedikasi. *Generics: Journal of Research in Pharmacy*, 2(1):9–15. https://doi.org/10.14710/genres.v2i1.12271

Amanda, D., Agustina, R., & Linuhung, N. 2020. Pengembangan media pembelajaran berbasis android menggunakan android studio pada materi turunan. *Emteka: Jurnal Pendidikan Matematika*, 1(1):46–53. https://doi.org/10.24127/emteka.v1i1.380

Anagün, Ş.S. 2018. Teachers’ perceptions about the relationship between 21st century skills and managing constructivist learning environments. *International Journal of Instruction*, 11(4): 825–840. https://www.e-iji.net/dosyalar/iji_2018_4_52.pdf

Ariani, D.P. & Puspasari, D. 2022. Pengembangan media pembelajaran interaktif berbasis power live quiz pada materi mail handling di SMKN 10 Surabaya. *Jurnal Pendidikan Tambusai*, 6(2):14800–14815.

Arif, S. & Muthoharoh, A.N. 2021. Pengembangan media pembelajaran berbasis powtoon dalam meningkatkan kemampuan representasi IPA di tengah pandemi Covid 19. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 5(1):112–124. https://jurnal.usk.ac.id/JIPI/article/view/19779

Aryani, I., Pramudita, D.A., Sinangkling, N.N., & Tama, I.D.A. 2023. Development of android-based learning media applications to determine validity and feasibility for grade VII middle school students on ecosystem material. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 7(1):72–85. https://jurnal.usk.ac.id/JIPI/article/view/28885

Barata, G., Gama, S., Jorge, J., & Gonçalves, D. 2013, September. Engaging engineering students with gamification. 2*013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)*, 1-8. IEEE.

Bungawati, B., & Rahmadani, E. 2023. Development of powtoon based science learning media in Elementary Schools. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):265-275. http://dx.doi.org/10.24815/jpsi.v11i2.27687

Cha, S.S. & Seo, B.K. 2018. Smartphone use and smartphone addiction in middle school students in Korea: Prevalence, social networking service, and game use. *Health Psychology Open*, 5(1):2055102918755046.

Cahyana, U., Supatmi, S., Erdawati, & Rahmawati, Y. 2019. The Influence of web-based learning and learning independence toward student's scientific literacy in chemistry course. *International Journal of Instruction*, 12(4):655–668. https://doi.org/10.29333/iji.2019.12442a

Churiyah, M., Sholikhan, S., Filianti, F., & Sakdiyyah, D.A. 2020. Indonesia education readiness conducting distance learning in covid-19 pandemic situation. *International Journal of Multicultural and Multireligious Understanding*, 7(6):491–507. https://doi.org/10.18415/ijmmu.v7i6.1833

Cimer, A. 2012. What makes biology learning diffiucult and effective: students' views. *Educational Research and Reviews*, 7(3): 61–71.

Fauzi, A. & Mitalistiani. 2018. Materi biologi sekolah menengah atas (SMA) yang dianggap sulit oleh mahasiswa sarjana strata 1. *Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi*, 2(2): 73–84. https://doi.org/10.32502/dikbio.v2i2.1242

Fauzi, A., Yudha, B., Harli, E., Kusmanto, T.H., Rangka, I.B., & Sapriyanti, S. 2019. Developing of TaPe game App for interactive learning based on DGBL model for students in elementary school. *Journal of Physics: Conference Series*, 1318(1):6–11. https://doi.org/10.1088/1742-6596/1318/1/012034

Febrianto, P.Y., Mas'udah, S., & Megasari, L.A. 2020. Implementation of online learning during the covid-19 pandemic on Madura Island, Indonesia, *International Journal of Learning, Teaching and Educational Research*, 19(8):233–254, https://doi.org/10.26803/ijlter.19.8.13

Hafzah, N., Puri Amalia, K., Lestari, E., Annisa, N., Adiatmi, U., & Saifuddin, M.F. 2020. Meta-analisis efektivitas penggunaan media pembelajaran digital dalam peningkatan hasil dan minat belajar biologi peserta didik di era revolusi industri 4.0. *Biodik: Jurnal Ilmiah Pendidikan Biologi*, 6(4):541–549. https://doi.org/10.22437/bio.v6i4.8958

Iqbal, S. & Bhatti, Z.A. 2020. A qualitative exploration of teachers’ perspective on smartphones usage in higher education in developing countries, *International Journal of Educational Technology in Higher Education*, 17-29. https://doi.org/10.1186/s41239-020-00203-4

Kongvitayanont, V., Pipitrat, P., Sathong, K., & Tangsripairoj, S. 2017. Bloody buddy : a biology game-based learning application. *2017 6th ICT International Student Project Conference (ICT-ISPC)*, *IEEE*, 1–4. https://doi.org/10.1109/ICT-ISPC.2017.8075297

Kristanto, A., Mustaji, Mariono, A., Sulistiowati, & Afifah. 2019. Development of education game media for XII multimedia class students in Vocational School. *Journal of Physics.: Conference Series.* 1387 01211:1–7. https://doi.org/10.1088/1742-6596/1387/1/012117

Latifah, S., Yuberti, Y., & Agestiana, V. 2020. Pengembangan media pembelajaran interaktif berbasis hots menggunakan aplikasi lectora inspire. *Jurnal Penelitian Pembelajaran Fisika*, 11(1):9–16. https://doi.org/10.26877/jp2f.v11i1.3851

Machmud, K. 2018. The smartphone ese in indonesian schools : the high school students’ perspective. *Journal of Arts and Humanities (JAH)*, 7(3):33–40. http://dx.doi.org/10.18533/journal.v7i3.1354

Manggopa, K.H., Komansilan, T., Kumajas, S., & Batmetan, J.R. 2022. Storyboard development for geospatial e-tourism based augmented reality. *International Journal of Information Technology and Education (IJITE)*, 1(3):56–70. http://ijite.jredu.id/index.php/ijite/article/view/59

Mohanty, A., Alam, A., Sarkar, R., & Chaudhury, S. 2021. Design and development of digital game-based learning software for incorporation into school syllabus and curriculum transaction. *Design Engineering*, 8:4864-4900.

Mudasih, I. & Subroto, W.T. 2019. Comparison of student learning outcomes through video learning media with powerpoint. *International Journal of Educational Research Review*, 4(2):183–189. https://doi.org/10.24331/ijere.517997

Mulyani, M.A., Razzaq, A., Sumardi, W.H., & Anshari, M. 2019. Smartphone adoption in mobile learning scenario. *Proceedings of 2019 International Conference on Information Management and Technology, ICIMTech 2019*, 1(2):208–211. https://doi.org/10.1109/ICIMTech.2019.8843755

Mulyana, T.D., Wahyuni, S., & Rusdianto, R. 2023. Development of powtoon-based animated videos to improve critical thinking skills Middel School Students In Science Learning. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 7(2):145-155. https://jurnal.usk.ac.id/JIPI/article/view/30066

Muthmainnah, Fatmawati, & Khairani, M. 2022. *Pemanfaatan dan pengembangan media pembelajaran*. Media Sains Indonesia.

Panjaitan, R.G.P., Titin, & Putri, N.N. 2020. Multimedia interaktif berbasis game edukasi sebagai media pembelajaran materi sistem pernapasan di kelas XI SMA. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 8(1):141–151. https://doi.org/10.24815/jpsi.v8i1.16062

Pramuditya, S.A., Rozak, A., & Rukmana, D. 2019. Solid geometry educational game based on student’s mathematical understanding. *Journal of Physics: Conference Series.* 1360

012013. https://doi.org/10.1088/1742-6596/1360/1/012013

Prasasti, F.D., Situmorang, R., & Kusumawardani, D. 2018. Development of integrated audio visual module for learning animation principles at multimedia vocational school. *International Journal of Education, Information Technology, and Others*, 1(2):55–69. https://doi.org/10.5281/zenodo.1795345

Qumillaila, Q., Susanti, B.H., & Zulfiani, Z. 2017. Pengembangan augmented reality versi android sebagai media pembelajaran sistem ekskresi manusia. *Cakrawala Pendidikan*, 1:57–69.

Rahaman, A., Tasnim, S., Majumdar, M.S.H., & Hossen, E. 2020. A comprehensive study on excessive mobile phone use and preventive measures. *International Journal of Modern Education & Computer Science*, 12(3):33-39. https://www.mecs-press.org/ijmecs/ijmecs-v12-n3/IJMECS-V12-N3-5.pdf.

Ramdani, A., Jufri, A.W., & Jamaluddin, J. 2020. Pengembangan media pembelajaran berbasis android pada masa pandemi covid-19 untuk meningkatkan literasi sains peserta didik. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran dan Pembelajaran*, 6(3):433–440. https://doi.org/10.33394/jk.v6i3.2924

Riduwan & Akdon. 2013. *Rumus dan data dalam analisis statistika*. Alfabeta.

Ritonga, M., Sartika, F., & Kustati, M. 2021. Madrasah al-ula for children: an effective learning management in the family during covid-19 pandemic. *Ilkogretim Online: Elementary Education Online*, 20(1):968–976. https://doi.org/10.17051/ilkonline.2021.01.97

Wibawanto, W. 2020. *Game edukasi RPG (Role Playing Game)*. LPPM UNNES.

Widodo, S.A. & Wahyudin. 2018. Selection of learning media mathematics for junior school students. *Turkish Online Journal of Educational Technology - TOJET*, 17(1):154–160.

Winarni, D.S., Naimah, J., & Widiyawati, Y. 2019. Pengembangan game edukasi science adventure untuk meningkatkan keterampilanpemecahan masalah siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 7(2):91-100. https://jurnal.usk.ac.id/JPSI/article/view/14462

Yaumi, M. 2018. *Media dan teknologi pembelajaran*. Prenadamedia Group.

Zahora, E. & Saparso. 2021. Penggunaan e-learning untuk meningkatkan minat dan hasil belajar bologi materi sistem saraf siswa kelas XI IPA 2 SMA "XYZ". *Journal of Innovation Research and Knowledge*, 1(3):297–304. https://www.bajangjournal.com/index.php/JIRK/article/view/200

Zulfiani, Z., Suwarna, I.P., & Miranto, S. 2021. Improving students' academic achievement using the ScEd-ALS. *International Journal of Instruction*, 14(2): 735–756. https://doi.org/10.29333/iji.2021.14241a

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The Effect Guided Discovery-Based Thermochemistry Module on Critical Thinking Skills of High School and Vocational Students

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Abstract. Critical thinking is a vital skill for success in higher education and the workforce. However, it is often inadequately emphasized in high school curricula, resulting in students lacking proficiency. Guided discovery-based modules provide a promising approach to enhancing critical thinking by fostering independent exploration and concept discovery. This study aimed to assess the effectiveness of a developed module in improving thermodynamics-related critical thinking skills among 10th-grade students in Boyolali Regency, Indonesia. Five schools were randomly selected, with two classes from each forming control and experimental groups. The experimental group utilized the developed module, while the control group used traditional textbooks. Validated by experts, a test was administered to evaluate students' critical thinking skills, and statistical analysis revealed a significant difference between the experimental and control groups. The developed module demonstrated superior efficacy in enhancing critical thinking skills compared to traditional textbooks. Variations in mean scores among the schools suggest the need for further investigation across diverse educational contexts. The study's outcomes have implications for teaching and learning in Indonesia and other countries where critical thinking is insufficiently emphasized in high school curricula. Ethical considerations were upheld, ensuring participant rights and confidentiality. Future research can explore the module's effectiveness in improving critical thinking across different subjects and educational settings.
Keywords: Guided discovery-based module; Critical thinking skills

Introduction

Critical thinking skills are highly valued in the 21st century as they help individuals to analyze, evaluate, and interpret information rationally and logically. These skills are essential for solving complex problems, making informed decisions, and adapting to new situations. Critical thinking skills are crucial in understanding the subject matter, analyzing chemical data, and designing experiments in chemistry learning (Alismail & Mcguire, 2015; Rodríguez-Becerra et al., 2020). Chemists use critical thinking skills to evaluate the accuracy and reliability of scientific information, identify patterns and trends, and draw conclusions based on evidence. Chemistry learning encourages students to develop critical thinking skills through hands-on experimentation, problem-solving, and scientific inquiry. Students are taught to ask questions, gather data, analyze results, and draw conclusions based on evidence. By applying critical thinking skills in chemistry, students learn to think independently, develop scientific literacy, and engage in scientific discourse (Feyzíoglu, 2012; Habig, 2020).

Developing critical thinking skills in thermochemistry is challenging for many high and vocational high school students. These skills are necessary to analyze, evaluate, and interpret information logically and are essential in science education to understand concepts, apply scientific methods, and solve problems. Without critical thinking skills, students may struggle to understand and apply thermochemistry concepts in real-world situations, making it a significant concern (Ambaryani et al., 2022; Wenno et al., 2021). Effective instructional approaches such as guided inquiry-based activities, problem-solving tasks, and scientific inquiry methods are needed to help students develop these skills. By utilizing these approaches, students can develop critical thinking skills essential for success in science-related fields and adapt to changing circumstances in the 21st century (Wass et al., 2014; Zhang et al., 2018).

Developing critical thinking skills in students is urgent because these skills are vital for success in the 21st century. The world is becoming more complex, and students must possess critical thinking skills to solve complex problems, make informed decisions, and adapt to changing circumstances (Salwan & Rahmatan, 2018). Critical thinking is especially crucial in science-related fields, where it is essential to understand and apply scientific concepts and methods. Students with critical thinking skills can analyze and evaluate data, draw conclusions, and make evidence-based decisions. They can also identify and solve problems through a logical and rational thought process (Aktam & Yenice, 2010; Valtonen et al., 2011). Science-related fields are becoming increasingly important in our society as we depend more on technology and seek solutions to global challenges. Therefore, students with strong critical thinking skills are better equipped to pursue successful careers in science-related fields and contribute to society's progres-progres (Almahdawi et al., 2021; Maulidar et al., 2016).The importance of critical thinking skills in science education will only increase as society and technology continue to evolve. The research on the guided discovery-based thermochemistry module on critical thinking skills of high school and vocational high school students could provide valuable insights into effective instructional approaches for developing these skills. Additionally, the findings could inform the development of instructional approaches for other science topics and contribute to the growing body of research on guided discovery-based approaches in science education. Ultimately, this study can potentially improve student learning outcomes and advance our understanding of effective science education practices (Levine et al., 2015; Park et al., 2017).

Previous studies have explored the development of critical thinking skills in science education, but none has investigated this area specifically in the context of thermodynamics. While some previous research has shown the effectiveness of discovery-based approaches in improving students' critical thinking skills in science, particularly in chemistry, no similar research has been conducted in thermodynamics (Moon et al., 2016; Putri et al., 2022). In previous studies, researchers employed different learning approaches, including problem-based, cooperative, and project-based learning. However, the current study utilized a guided discovery-based approach to developing students' critical thinking skills. This approach allows students to explore, discover, and construct knowledge independently while the teacher provides guidance and support (Levine et al., 2015; Martino et al., 2020).

The aim of this study is to investigate whether a guided discovery-based approach to learning can improve the critical thinking skills of high school and vocational students in the area of thermochemistry. The research intends to evaluate the impact of this approach on students' ability to think critically about thermochemistry concepts. Ultimately, the study aims to provide evidence regarding the effectiveness of the guided discovery-based approach to teaching and learning, and contribute to the development of better teaching methods in the future.

Methods

The study used a quasi-experimental design, where each school provided two sample classes: the control and experimental. The learning activities in the experimental class used the developed module, while the control class used textbooks commonly used in schools. The study used a pretest-posttest control group design to collect data on critical thinking skills. The study used cluster random sampling to select five schools in Boyolali Regency, Indonesia, willing to participate. The study selected two sample classes from each school, the control and experimental. Aiken analysis, a statistical method used to assess agreement among multiple raters or validators, was employed to validate the module and instrument used in the study. The validators comprised two linguists, three media experts, and two chemistry learning experts. The Aiken validity coefficient for the module and instrument was determined to be 0.75 or greater, indicating that the module and instrument's content aligns with the validators' assessments. This means that the module and instrument accurately measure the critical thinking skills related to thermodynamics they were intended to assess. Additionally, the statement notes that the instrument's reliability was assessed and found to be 0.87, indicating that the instrument's outcomes were consistent over time. The reliability test involved five students who had previously studied thermodynamics.

The study upheld participants' rights and ethical treatment by obtaining approval from the Faculty of Teacher Training and Education Ethics Committee at Sebelas Maret University. The researchers obtained written informed consent from participants and their parents or guardians and informed them about the study's purpose, their right to withdraw, and the confidentiality of their data. The study ensured that participants were not harmed and received equal opportunities regardless of their demographic characteristics. The researchers maintained confidentiality and removed identifiable information from the data before analyzing it (Hafizan et al., 2010).

The study involved 309 10th-grade high school students from Boyolali Regency, Indonesia, with 157 students in the control group and 152 students in the experimental group. Five schools participated in the study, including three Senior High Schools (SMA) and two Vocational Schools (SMK). Cluster random sampling was used to select control and experimental classes from each school, and random sampling was used to assign students to either group. The experimental group used a specially developed module, while the control group used textbooks commonly used in schools. In addition, the study used a pretest-posttest control group design to collect data on skills (Saputra et al., 2018; Soyadı, 2015)

Regarding data analysis, the study underwent validity testing using Aiken analysis, which involved seven validators, including linguists, media experts, and chemistry learning experts. The Aiken validity coefficient for the module and instrument was 0.75 or higher, indicating agreement between the content and validators' judgments. The instrument's reliability was also tested and found to be 0.87, indicating consistency in results over time. Data were analyzed using appropriate statistical techniques, and any significant differences between the experimental and control groups were noted.Researchers conducted a normality test to ensure the data had a normal distribution, a prerequisite for most statistical tests. To verify the comparability of the two groups and ensure that the differences between them were due to the treatment. A homogeneity test was also carried out to confirm equal data variance. To compare the mean scores of the control and experimental groups, the researchers employed a t-test. This statistical method examines whether there is a significant difference between the means of the two groups. The t-test was used to investigate the critical thinking skills of students who used the developed module versus those who used the traditional textbook. Next, the ANOVA test was used to determine if there were any significant differences in the mean scores among the five schools. The Scheffe test was then used as a post hoc test to identify which schools were responsible for the significant differences observed in the ANOVA test. Finally, the researchers used the N-gain score to measure the improvement in students' critical thinking skills. The N-gain score calculates the difference between a student's pretest and posttest scores, indicating the effectiveness of the developed module in enhancing students' critical thinking skills (Abbas et al., 2023; Susetyo et al., 2021).

Table 1. Homogeneity, normality comparison test results

School	Sig	
	Homogenity	Normality
A	0.06	*0.091*
B	0.09	0.121
C	0.200	0.200
D	0.200	0.200
E	0.200	0.200

Table 1 shows the results of the homogeneity and normality comparison test for several schools.Homogeneity refers to the similarity of variance between groups. In the table, the Sig value for homogeneity indicates the significance level of the null hypothesis that the groups have the same variance. The larger the Sig value, the greater the possibility that the groups have different variances. Normality refers to the distribution of data within each group. In the table, the Sig value for normality indicates the significance level of the null hypothesis that the data within the group has a normal distribution. The smaller the Sig value, the closer the distribution of data is to a normal distributionIn this case, all the Sig values for normality are greater than the commonly used significance level (usually 0.05), so it cannot be ignored that the groups have a non-normal distribution. The Sig values for homogeneity of all groups are sufficiently large, so it cannot be ignored that the groups have the same variance.

Results and Discussion

The study occurred in five schools in Boyolali Regency, consisting of three SMA and two SMK. Two classes were selected from each school, one assigned as the control group and the other as the experimental group. The experimental group used the developed module during their learning activities, while the control group used the commonly used textbooks. To ensure that the data met the statistical test assumptions, normality and homogeneity tests were conducted on both groups. To measure the module's effectiveness in enhancing critical thinking skills, we compared the test scores of both groups before and after studying the topic thermochemical. We performed hypothesis testing using t-test analysis with SPSS, and you can find the results in Table 2.

Table 2. The results of hypothesis testing on improving students' critical thinking skills from the sample class.

School	class group	N	mean	S	Sig
A	Control	34	0.9641	0.3506	0.008
	Experiment	33	1.1858	0.3075	
B	Control	36	0.6811	0.2281	0.000
	Experiment	36	0.9025	0.1339	
C	Control	32	0.6709	0.2026	0.004
	Experiment	31	0.7981	0.1303	
D	Control	32	0.5013	0.1993	0.036
	Experiment	30	0.6060	0.1830	
E	Control	23	0.5957	0.2675	0.046
	Experiment	22	0.7364	0.1820	

The study utilized the N-gain score, which was obtained by subtracting the pretest score from the posttest score and dividing it by the difference between the maximum score and the pretest score, for data analysis. Table 2 displays the significance values for each school: school A (0.008), school B (0.000), school C (0.004), school D (0.036), and school E (0.046). These values, smaller than the significance level of 0.05, indicate the rejection of the null hypothesis (H0) and acceptance of the alternative hypothesis (H1). Hence, a significant difference in critical thinking skill improvement exists between the control and experimental classes, where the experimental classes employed guided discovery-based module development.

Table 3 presents the results of an ANOVA test conducted to assess the differences in improving critical thinking skills among the five schools. The obtained significance value in Table 3 is 0.000, which is lower than the significance level of 0.05, indicating significant variations in the enhancement of critical thinking skills among the sample schools. To identify the specific schools contributing to these differences, the Scheffe test was employed, and the outcomes are outlined in Table 4. In Table 2, notable improvement in students' critical thinking skills is observed across all schools that implemented guided discovery-based module development. This finding aligns with previous research, such as the study (Chayati et al., 2020; Handayani et al., 2021), which reported an average increase score of 0.41 in critical thinking skills as a result of guided discovery-based module development. Despite the overall improvement, significant differences exist in the level of enhancement in critical thinking skills among the schools.

School B exhibited the highest significance value of 0.000, indicating the most substantial improvement in critical thinking skills within that particular school. Conversely, school E displayed the lowest significance value of 0.046, suggesting relatively limited progress in critical thinking skills. Schools A, C, and D demonstrated moderate significance values ranging from 0.004 to 0.036. It is worth noting that schools D and E were vocational schools, while schools A, B, and C were high schools. This distinction may offer an explanation for the observed variations. Vocational schools often emphasize technical and practical skills, such as in the field of thermodynamics. As a result, guided discovery-based modules may be less effective in improving critical thinking skills compared to high schools, which typically prioritize the development of broader academic skills. However, further research is necessary to validate this assumption.

The utilization of guided discovery-based modules in thermodynamics learning can be explained through constructivism and discovery learning theories. Constructivism posits that students should actively participate in constructing their knowledge, while discovery learning theory emphasizes self-discovery as an effective method for fostering deeper understanding. Guided discovery-based modules enable students to develop critical thinking skills and solve problems autonomously, with the teacher assuming the role of a facilitator (Ferrell et al., 2019; Satilmis, 2014). The differences in improving critical thinking skills among schools can be attributed to various factors, including teaching methods, teacher's competency, student motivation, and learning environment. School B had the most significant improvement in critical thinking skills, which may be due to the teachers' competence in implementing guided discovery-based modules, students' motivation to learn, and a conducive learning environment. Conversely, school E had the least improved critical thinking skills, possibly due to less competent teachers, lower student motivation, and a less conducive learning environment. The social cognitive theory by Albert Bandura explains the differences in learning outcomes between schools. This theory suggests that learning is influenced by personal, behavioral, and environmental factors, including cognitive, emotional, and biological characteristics, learning strategies, and physical and social conditions that affect learning. The significant differences in improving critical thinking skills among schools can be explained using this theory (Maknun, 2019; Wenno et al., 2021).

Table 3. The results of the oneway Anova test for increasing critical thinking skills in the experimental class

	Sum of squares	Df	Mean squares	F	Sig
Between groups	4,183	20	1,046	17,503	0,000
Within groups	8,784	147	0,060		
Total	12,967	151			

According to the results presented in Table 3, the ANOVA test indicated a significant difference in improving critical thinking skills among the five schools. Furthermore, the p-value obtained from the test was less than the predetermined significance level of 0.05, which led to the rejection of the null hypothesis (H0), indicating significant differences in improving critical thinking skills among the schools.

To determine which school(s) were responsible for the observed differences, a Scheffe test was conducted as a posthoc test following the ANOVA. The Scheffe test is used to identify which groups significantly differ from one another. Table 4 presents the outcomes of the Scheffe test performed on the five schools in the sample. The table shows the mean differences, standard error, Scheffe values, and significance levels between each pair of schools (Chayati et al., 2020; Hastani et al., 2021). This information helps determine which schools are significantly different from each other regarding critical thinking skills improvement. The Scheffe test provides a useful tool for researchers to identify specific differences between groups, and it can help to identify where interventions may be most effective.

Further research is necessary to confirm the assumption that vocational schools may have a stronger tendency to teach technical and practical skills and to investigate the effectiveness of guided discovery-based modules in enhancing critical thinking skills in diverse educational settings (Feyzíoglu, 2012). Therefore, a Scheffe test was performed as a follow-up ANOVA test to determine which school was responsible for this difference. The Scheffe test is a posthoc test used to determine which groups are significantly different from each other after a significant difference has been detected through an ANOVA test. It is used to compare all possible combinations of groups and to determine which groups have a significant difference in mean scores (Dewi et al., 2022; Nuraisyah et al., 2020).

Several studies have supported the use of guided discovery-based modules in improving critical thinking skills among students. For example, a study by (Handayani et al., 2021; Levine et al., 2015) found that guided discovery-based modules significantly improved critical thinking skills among nursing students. Another study (Nuraisyah et al., 2020)found that guided discovery-based teaching methods effectively improved the critical thinking skills of high school students in science courses. These studies provide additional support for the theoretical basis of using guided discovery-based modules to improve students' (Pratiwi et al., 2021). Using guided discovery-based modules in thermodynamics learning can help improve students' critical thinking skills in problem-solving. Critical thinking skills are essential in chemistry learning to understand abstract and complex chemical concepts. Additionally, chemistry learning requires applying critical thinking skills in interpreting data and drawing appropriate conclusions from experimental or research results. Constructivism and discovery theories state that students should actively construct their knowledge and learn through self-discovery (Maknun, 2020). In this context, guided discovery-based modules allow students to acquire knowledge more effectively, as they can discover knowledge with guidance from the teacher. In this way, students can better understand chemical concepts and develop their critical thinking skills in solving chemistry problems. Using guided discovery-based modules in thermodynamics learning successfully improved students' critical thinking skills across all schools involved in the study. However, there were significant differences in the level of improvement in critical thinking skills between the schools. Therefore, using guided discovery-based modules in thermodynamics learning can benefit students from different types of high or vocational schools (Feyzíoglu, 2012).

Table 4. Scheffe test results increase critical thinking skills in the experimental class.

				95% Confidence Interval	
(I) School	(J) School	Std. Error	Sig.	Lower Bound	Upper Bound
A	B	.05891	.005	.0492	.4168
	C	.06114	.000	.1222	.5037
	D	.06166	.000	.3000	.6848
	E	.06728	.000	.1524	.5722
B	A	.05891	.005	-.4168	-.0492
	C	.05989	.775	-.1069	.2668
	D	.06043	.002	.0709	.4480
	E	.06615	.434	-.0771	.3357
C	A	.06114	.000	-.5037	-.1222
	B	.05989	.775	-.2668	.1069
	D	.06260	.090	-.0158	.3748

	E	.06814	.971	-.1633	.2619
D	A	.06166	.000	-.6848	-.3000
	B	.06043	.002	-.4480	-.0709
	C	.06260	.090	-.3748	.0158
	E	.06861	.466	-.3442	.0839
E	A	.06728	.000	-.5722	-.1524
	B	.06615	.434	-.3357	.0771
	C	.06814	.971	-.2619	.1633
	D	.06861	.466	-.0839	.3442

The results of the ANOVA test, Scheffe test, and N-gain score calculations to evaluate students' critical thinking skills in each school are presented in Table 4. The table reveals a significant difference in improving critical thinking skills among the five schools, with a significance value of less than 0.05, leading to rejecting H0. In addition, a Scheffe test was conducted as a follow-up ANOVA test to identify which school contributed to this difference.

In the first part of the table, it can be seen that there is a significant difference in improving critical thinking skills between schools A and B, C, D, and E. In the second part, school B exhibits a significant difference in improvement compared to schools A and D. However, schools C and E do not significantly improve students' critical thinking skills, as the significance value towards school B is greater than 0.05.

The third part of the table illustrates that school C significantly improves critical thinking skills compared to school A only. In the fourth part, school D has a significant difference in improvement compared to schools A and B. Lastly, school E shows a significant difference in improvement compared to school A. Based on the data presented in Table 3, it can be inferred that school A has the most significant improvement in critical thinking skills compared to the other schools. Additionally, it is worth noting that school A is situated on the outskirts of Boyolali Regency, an area characterized by teak forests and scattered population settlements, which may affect the improvement of students' skills.

The results of the Scheffe test suggest a significant difference in improving students' critical thinking skills between schools A, B, C, D, and E. This finding is consistent with previous research showing that different types of schools can have varying impacts on students' critical thinking skills. In addition, schools A, B, and C are high schools, while schools D and E are vocational schools is also worth noting. Previous studies have suggested that vocational education may not promote critical thinking skills as effectively as academic education. However, the results of the Scheffe test in this study suggest that schools D and E did not necessarily perform worse than schools A, B, and C in improving students' critical thinking skills. This finding suggests that vocational education may not always hinder critical thinking skill development (Ambaryani et al., 2022; Bagheri & Nowrozi, 2015; Erna et al., 2021)

Regarding chemistry education, critical thinking skills are essential for students to become proficient in problem-solving and decision-making in the laboratory and beyond. Therefore, it is important for chemistry educators to develop effective strategies to enhance students' critical thinking skills (Pratiwi et al., 2021). The results of this study suggest that the Scheffe test can be used to evaluate the effectiveness of such strategies in improving students' critical thinking skills. Based on the Scheffe test results in Table 3, it can be inferred that the experimental class in school A showed the most significant improvement in critical thinking skills compared to the other schools. This finding is consistent with previous research suggesting that certain teaching methods, such as problem-based, inquiry-based (Chayati et al., 2020).Critical thinking skills are essential for students to understand the principles and concepts of chemistry and apply them to real-world problems. Therefore, it is crucial to integrate teaching strategies that promote critical thinking skills into chemistry education (Singhal, 2020). For example, inquiry-based learning, where students conduct their investigations and experiments, can develop critical thinking skills by encouraging students to ask questions, make observations, and draw conclusions based on evidence. Additionally, problem-based learning, where students are presented with real-world problems and work collaboratively to solve them, can promote critical thinking skills by requiring students to analyze and evaluate information to develop solutions (Hmelo-Silver & Pfeffer, 2004)

In the context of vocational schools (SMK), the development of critical thinking skills holds significant importance, as these skills are essential for students to effectively apply their acquired knowledge and skills in the workplace. In addition to the teaching strategies mentioned earlier, vocational schools can incorporate hands-on learning and industry-based projects to further enhance critical thinking abilities among their students.One approach is to provide students with opportunities for practical application through apprenticeships, internships, or industry-based competitions. By participating in these real-world experiences, students are able to apply their knowledge and skills to solve authentic problems and develop innovative solutions. This hands-on approach not only reinforces their understanding of theoretical concepts but also nurtures their ability to think critically and adapt their knowledge in practical settings.The effectiveness of integrating industry-based projects and experiential learning in vocational education. These activities foster critical thinking skills by requiring students to analyze complex situations, think creatively, and make informed decisions based on their knowledge and expertise (Bagheri & Nowrozi, 2015; Samani et al., 2019; Tappura et al., 2017). Furthermore, students learn to collaborate with industry professionals, communicate effectively, and develop a deeper understanding of the demands and expectations of the workplace. By integrating hands-on learning and industry-based projects, vocational schools can provide a more comprehensive education that aligns with the practical demands of the workforce. This approach not only enhances students' critical thinking skills but also prepares them for successful transitions into their chosen careers (Aktam & Yenice, 2010; Jing-Jing, 2014; Nielsen, 2013).

The Scheffe post hoc test analysis of the data collected from the study indicated that the experimental class in school A had the most significant improvement in critical thinking skills compared to the other classes. This improvement is essential for success in chemistry education and the workplace, as critical thinking skills enable students to analyze complex information and make informed decisions (Almahdawi et al., 2021; Chayati et al., 2020). The study's results have important implications for educators, emphasizing the importance of incorporating teaching strategies that promote critical thinking skills into their curriculum, especially in chemistry education and vocational schools. In addition, the study suggests that educators can use module-based instruction, such as the one used in the study, to enhance critical thinking skills among their students (Abbas et al., 2023). The study also highlights the importance of considering different types of schools in evaluating the effectiveness of interventions to improve students' critical thinking skills (Fahrunisa et al., 2020). The findings suggest that effective strategies can be developed to enhance critical thinking skills in both academic and vocational education settings (Chayati et al., 2020). This is important because there has been a perception that vocational education may not necessarily develop critical thinking skills, but the study's findings challenge this perception (Barke et al., 2009). The study demonstrated ethical considerations in upholding the participants' rights and maintaining confidentiality. Future research can explore the effectiveness of the developed module in enhancing critical thinking skills in other subjects and educational contexts. Nevertheless, the study provides evidence that the developed module effectively enhances critical thinking skills related to thermodynamics among high school students in Boyolali Regency, Indonesia. The study's findings support the importance of incorporating critical thinking skill development into the curriculum, which can benefit students in their education and future careers (Hambleton & Jones, 1993).

Conclusion

The study showed that using guided discovery-based modules in thermodynamics learning can significantly improve students' critical thinking skills. The results were consistent with previous research, which found that guided discovery-based modules effectively improved critical thinking skills in various fields. The significant differences in the level of improvement in critical thinking skills between schools could be attributed to various factors, such as teaching methods, teacher's competency, student's motivation, and learning environment. The study suggests that vocational schools may have a stronger tendency to teach technical and practical skills. Therefore, guided discovery-based modules may not be as effective in improving critical thinking skills in vocational schools as in high schools. However, constructivism theory and discovery learning theory support the theoretical basis for using guided discovery-based modules. The study provides evidence for the effectiveness of guided discovery-based modules in improving critical thinking skills in chemistry learning. Critical thinking skills are essential in understanding complex chemical concepts and interpreting data. Further research is needed to confirm the study's assumptions and explore the effectiveness of guided discovery-based modules in improving critical thinking skills in different educational contexts.

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References

Abbas, S., Umangap, W.A., & Amin, A.M. 2023. Collaborative group investigation and self efficacy on pre-service science teachers' critical thinking skills. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1):1–11. https://doi.org/10.24815/jpsi.v11i1.26614

Aktam, H. & Yenice, N. 2010. Determination of the science process skills and critical thinking skill levels. *Procedia-Social and Behavioral Sciences*, 2(2):3282–3288. https://doi.org/10.1016/j.sbspro.2010.03.502

Alismail, H.A. & Mcguire, P. 2015. 21 st century standards and curriculum : current research and practice. *Journal of Education and Practice*, 6(6):150–155. https://www.iiste.org/Journals/index.php/JEP/article/view/20055/20413

Almahdawi, M., Senghore, S., Ambrin, H., & Belbase, S. 2021. High school students' performance indicators in distance learning in chemistry during the covid-19 pandemic. *Education Sciences*, 11(11):672-682. https://doi.org/10.3390/educsci11110672

Ambaryani, S.E., Sarwanto, S., & Budiawanti, S. 2022. Learning physics using search, solve, create, share and preview, question, read, reflect, recite, review models analyzed from critical thinking and problem-solving skills on student learning outcomes. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(3):592–605. https://doi.org/10.24815/jpsi.v10i3.25143

Bagheri, M. & Nowrozi, R.A. 2015. A comparative study of the critical thinking skills among the students of accounting and software in the female technical and vocational university in the city of borojerd. *Journal of Education and Practice*, 6(13):43–46. https://login.ezproxy.elib11.ub.unimaas.nl/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1080601&site=ehost-live&scope=site

Barke, H. D., Hazari, A., & Yitbarek, S. 2008. Misconceptions in chemistry: Addressing perceptions in chemical education. Berlin-Heidelberg: Springer-Verlag: 1–294. https://doi.org/10.1007/978-3-540-70989-3

Chayati, N., Masykuri, M., & Utomo, S.B. 2020. Development learning cycle 5e module integrated with science, technology, engineering, and mathematics (STEM) in thermochemistry. *JKPK (Jurnal Kimia Dan Pendidikan Kimia)*, 5(3):282-292. https://doi.org/10.20961/jkpk.v5i3.38938

Dewi, C.A., Awaliyah, N., Fitriana, N., Darmayani, S., Nasrullah, Setiawan, J., & Irwanto, I. 2022. Using android-based e-module to improve students' digital literacy on chemical bonding. *International Journal of Interactive Mobile Technologies*, 16(22): 191–208. https://doi.org/10.3991/ijim.v16i22.34151

Dwi Saputra, M., Joyoatmojo, S., & Kusuma Wardani, D. 2018. The assessment of critical-thinking-skill tests for accounting students of vocational high schools. *International Journal of Educational Research Review*, 3(4):85–96. https://doi.org/10.24331/ijere.453860

Erna, M., Elfizar, & Dewi, C.A. 2021. The Development of e-worksheet using kvisoft flipbook maker software based on lesson study to improve teacher's critical thinking ability. *International Journal of Interactive Mobile Technologies*, 15(1): 39–55. https://doi.org/10.3991/IJIM.V15I01.15679

Fahrunisa, A., Mustadi, A., Toto, R.W., & Pudjiastuti, P. 2020. An analysis of the scientific attitudes of fifth graders through guided discovery learning. *Jurnal Penelitian Dan Pembelajaran IPA*, 6(2):225-232. https://doi.org/10.30870/jppi.v6i2.4704

Ferrell, J.B., Campbell, J.P., McCarthy, D.R., McKay, K.T., Hensinger, M., Srinivasan, R., Zhao, X., Wurthmann, A., Li, J., & Schneebeli, S.T. 2019. Chemical exploration with virtual reality in organic teaching laboratories. *Journal of Chemical Education*, 96(9):1961–1966. https://doi.org/10.1021/acs.jchemed.9b00036

Feyzíoglu, B. 2012. Developing a science process skills test for secondary students : validity and reliability study *educational sciences: Theory and Practice,* 12(2007): 1899–1906. https://eric.ed.gov/?id=EJ1000902

Habig, S. 2020. Who can benefit from augmented reality in chemistry? Sex differences in solving stereochemistry problems using augmented reality. *British Journal of Educational Technology*, 51(3):629–644. https://doi.org/10.1111/bjet.12891

Hafizan, E., Shahali, M., & Halim, L. 2010. *Development and validation of a test of integrated science process skills.* 9:142–146. https://doi.org/10.1016/j.sbspro.2010.12.127

Hambleton, R.K. & Jones, R.W. 1993. An NCME instructional module on comparison of classical test theory and item response theory and their applications to test development items: Instructional topics in educational measurement. *Educational Measurement: Issues and Practice*, 12(3):38–47. http://solo.bodleian.ox.ac.uk/OXVU1:TN_ericEJ471935

Handayani, D., Elvinawati, Isnaeni, & Alperi, M. 2021. Development of guided discovery based electronic module for chemical lessons in redox reaction materials. *International Journal of Interactive Mobile Technologies*, 15(7):94–106. https://doi.org/10.3991/ijim.v15i07.21559

Hastani, F.S., Sudarmin, S., & Pancawardhani, H. 2021. The critical problem solving (cps) e-module development on ethnoscience-integrated thermochemistry topics. *International Journal of Active Learning*, 6(2):91–99. https://journal.unnes.ac.id/nju/index.php/ijal/article/view/31147

Hmelo-Silver, C.E. & Pfeffer, M.G. 2004. Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. *Cognitive Science*, 28(1):127–138. https://doi.org/10.1016/S0364-0213(03)00065-X

Jing-Jing, H. 2014. A critical review of Pedagogical Content Knowledge' components: nature, principle and trend. *International Journal of Education and Research*, 2(4): 411–424. https://doi.org/10.3102/0034654311423382

Levine, M., Serio, N., Radaram, B., Chaudhuri, S., & Talbert, W. 2015. Addressing the STEM gender gap by designing and implementing an educational outreach chemistry camp for middle school girls. *Journal of Chemical Education*, 92(10): 1639–1644. https://doi.org/10.1021/ed500945g

Maknun, J. 2019. The development of critical thinking skills in vocational high school students in Indonesia. *International Journal of Innovation, Creativity and Change*, 7(12):237–258. https://www.ijicc.net/images/vol7iss12/71223_Maknun_2019_E_R.pdf

Maknun, J. 2020. Implementation of guided inquiry learning model to improve understanding physics concepts and critical thinking skill of vocational High School

Students. *International Education Studies*, 13(6):117-130 https://doi.org/10.5539/ies.v13n6p117

Martino, M., Salvadori, A., Lazzari, F., Paoloni, L., Nandi, S., Mancini, G., Barone, V., & Rampino, S. 2020. Chemical promenades: Exploring potential-energy surfaces with immersive virtual reality. *Journal of Computational Chemistry*, 41(13):1310–1323. https://doi.org/10.1002/jcc.26172

Maulidar, N., Yusrizal, Y., & Halim, A. 2016. Pengaruh penerepan model pembelajaran guided discovery terhadap kemampuan pemahaman konsep dan ketrampilan berpikir kritis siswa smp pada materi kemagnetan. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 4(2):69–75. https://jurnal.usk.ac.id/JPSI/article/view/7581

Moon, A., Stanford, C., Cole, R., & Towns, M. 2016. The nature of students' chemical reasoning employed in scientific argumentation in physical chemistry. *Chemistry Education Research and Practice*, 17(2):353–364. https://doi.org/10.1039/c5rp00207a

Nielsen, J.A. 2013. dialectical features of students' argumentation: a critical review of argumentation studies in science education. *Research in Science Education*, 43(1): 371–393. https://doi.org/10.1007/s11165-011-9266-x

Nuraisyah, A.D., Saputro, S., & Susilowati, E. 2020. Effectiveness of guided discovery based thermochemistry module to train critical thinking skills based on gender differences. *JTK (Jurnal Tadris Kimiya)*, 5(1):118–130. https://doi.org/10.15575/jtk.v5i1.8149

Park, M., Liu, X., & Waight, N. 2017. Development of the connected chemistry as formative assessment pedagogy for High School Chemistry Teaching. *Journal of Chemical Education*, 94(3):273–281. https://doi.org/10.1021/acs.jchemed.6b00299

Pratiwi, B., Copriady, J., & Anwar, L. 2021. Implementation of phenomenon-based learning e-module to improve critical thinking skills in thermochemistry material. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(4): 579–589. https://doi.org/10.24815/jpsi.v9i4.21114

Putri, P.A.W., Rahayu, S., Widarti, H.R., & Yahmin, Y. 2022. Chemistry students' digital literacy skills on thermochemistry context "hydrogen fuel issue". *Eurasia Journal of Mathematics, Science and Technology Education*, 18(12):em2198. https://doi.org/10.29333/ejmste/12699

Rodríguez-Becerra, J., Cáceres-Jensen, L., Díaz, T., Druker, S., Bahamonde Padilla, V., Pernaa, J., & Aksela, M. 2020. Developing technological pedagogical science knowledge through educational computational chemistry: A case study of pre-service chemistry teachers' perceptions. *Chemistry Education Research and Practice*, 21(2):638–654. https://doi.org/10.1039/c9rp00273a

Salwan, S. & Rahmatan, H. 2018. Pengaruh LKPD berbasis discovery learningterhadap peningkatan hasil belajar siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 5(2):25–31. https://doi.org/10.24815/jpsi.v5i2.9812

Samani, M., Sunwinarti, S., Putra, B.A.W., Rahmadian, R., & Rohman, J.N. 2019. Learning strategy to develop critical thinking, creativity, and problem-solving skills for vocational school students. *Jurnal Pendidikan Teknologi dan Kejuruan*, 25(1): 36–42. https://doi.org/10.21831/jptk.v25i1.22574

Satilmis, Y. 2014. Misconceptions about periodicity in secondary chemistry education: the case of kazakhstan. *International Online Journal of Primary Education*, 3(2):53–58. https://iojpe.org/index.php/iojpe/article/view/121

Singhal, M.K. 2020. Facilitating virtual medicinal chemistry active learning assignments using advanced zoom features during covid-19 campus closure. *Journal of Chemical Education*, 97(9):2711–2714. https://doi.org/10.1021/acs.jchemed.0c00675

Susetyo, B., Siswaningsih, W., & Oktavi, F.R. 2021. Development of critical thinking test instruments with problem solving context on the salt hydrolysis material. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(2):243–255. https://doi.org/10.24815/jpsi.v9i2.19862

Tappura, S., Teperi, A., & Kurki, A. 2017. The management of occupational health and safety in vocational education and training sari. *AHFE 2017 International Conference on Human Factors in Training, Education, and Learning Sciences*, 596:452–461. https://doi.org/10.1007/978-3-319-60018-5

Valtonen, T., Pontinen, S., Kukkonen, J., Dillon, P., Väisänen, P., & Hacklin, S. 2011. Confronting the technological pedagogical knowledge of Finnish Net Generation student teachers. *Technology, Pedagogy and Education*, 20(1):3–18. https://doi.org/10.1080/1475939X.2010.534867

Wass, R., Harland, T., & Mercer, A. 2014. Sharpening a tool for teaching: The zone of proximal development. *Teaching in Higher Education*, 19(6):671–684. https://doi.org/10.1080/13562517.2014.901958

Wenno, I.H., Jamaludin, J., & Batlolona, J.R. 2021. The effect of problem based learning model on creative and critical thinking skills in static fluid topics. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(3):498–511. https://doi.org/10.24815/jpsi.v9i3.20829

Yazar, S.B.B. 2015. Creative and Critical Thinking Skills in Problem-based Learning environments. *Journal of Gifted Education and Creativity*, 2(2):71-80. https://doi.org/10.18200/jgedc.2015214253

Zhang, J.F., Paciorkowski, A.R., Craig, P., & Cui, F. 2018. BioVR: A platform for virtual reality assisted biological data integration and visualization. *BioRxiv,* (April):1–10. https://doi.org/10.1101/307769

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Development of Project Based Learning With STEAM Approach Model in Improving the Science Literacy Ability of High School Students

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Abstract. Facing today's 21st century learning, teachers need to foster science literacy and consider learning strategies that are appropriate to the conditions and potential of learners. This study aims to develop a PjBL with STEAM approach model in improving science literacy ability of high school students. This study is a development research with the Borg & Gall development model. The sample of this study was class X students of SMAN 2 Selong, totaling 35 students. The instruments used to collect data include guidelines for validating learning design, practicality questionnaires and science literacy ability tests on ecosystem materials. The data analysis used in this study used descriptive analysis. Based on the validation analysis, the products developed are included in the valid category indicated by the average score of product validation by 3 experts, namely linguists, material experts and learning technology experts successively 83.91; 84.64 and 83.73. Similarly, in terms of practicality, the products developed are also classified as practical with an average practicality score of 82.63. The product is also classified as effective with a percentage of effectiveness of 88.57%. The product developed has a potential effect in the high category to improve science literacy ability on ecosystem materials with an N-Gain of 0.76.
Keywords: STEAM, Project Based Learning, Science Literacy

Introduction

The learning of the 21st century is characterized by the rapid development of science and technology in the sphere of life in society, especially information and communication technology. Currently, the world community is entering a new era, an era of accelerating changes in various aspects or fields including education. The demands of the 21st century make the education system must be in accordance with the changing times. Science literacy is very important for students to have as a provision to face the challenges of the development of the 21st century. Science literacy directly correlates with building a new generation that has strong scientific thoughts and attitudes that can effectively communicate science and research results to the general public. Based on PISA 2019, the science literacy ability of Indonesian students is still below average when compared to the average international yaitu peringkat 70 dari 78 negara (Mullis, 2019). The results of the 2019 PISA study are proof that Indonesian formal education emphasizes more on the aspects of low-level thinking and rarely accustoms students to use higher-order thinking in facing and solving real problems in everyday life (Durden, 2018).

Facing today's 21st century learning, teachers need to cultivate science literacy and consider learning strategies that are in accordance with the conditions and potentials of students where the learning process focuses on providing hands-on experience and applying the nature of science. Literacy skills are fundamental things that must be possessed by students in facing the global era to be able to meet the needs of life in various situations. Science literacy is the ability to understand science, communicate science, and apply science skills to solve problems. Science literacy can be defined as scientific knowledge and skills to be able to identify questions, acquire new knowledge, explain scientific phenomena, and take conclusions based on facts, understand the characteristics of science, awareness of how science and technology shape the natural, intellectual, and cultural environment, as well as the willingness to engage and care about issues related to science (OECD, 2019). A person has science and technology literacy characterized by having the ability to solve problems by using science concepts obtained in education according to their level, getting to know the technological products around them and their impacts, being able to use technological products and maintaining them, being creative in making simplified technological results so that students are able to make decisions based on community values and culture (Nunaki et al., 2019). The main elements contained in science literacy according to (Harlen, 2004), 1) concepts or ideas, which help understanding of scientific aspects of the world around and which enable us to make sense of new experiences by linking them to what we already know, 2). processes, which are mental and physical skills used in obtaining, interpreting and using evidence about the world around to gain knowledge and build understanding, 3). attitudes or dispositions, which indicate willingness and confidence to engage in enquiry, debate and further learning, 4). understanding the nature (and limitations) of scientific knowledge. With science literacy, students can have sensitivity in solving global problems, able to meet the various demands of the times, namely becoming competitive, innovative, collaborative, and characterful students.

The learning carried out by the teacher will affect the learning atmosphere carried out (Kilinc, 2018). Teachers need to design and manage learning by actively engaging students in learning that encourages students to learn (Mbhiza, 2021; Öztürk, 2020; Tsakeni, 2021). Project based learning (PjBL) gives teachers the opportunity to manage classroom learning by involving project work (Acar et al., 2018). PjBL is student-centered and gives students the opportunity to conduct in-depth investigations on essential topics (Yamin et al., 2020). PjBL is an activity where students can access knowledge and the teacher facilitates students in conducting investigations (Ramesh, 2020). PjBL requires students to design and develop systems that can be used to conduct investigations and solutions to real-world problems (Sababha, 2016). PjBL is a method in which students engage in intellectually challenging task tasks to gain knowledge and skills used in solving problems (Movahedzadeh, 2012). PjBL provides a structure for students to engage in every practice by taking steps to develop and implement projects (Baker, 2004). PjBL is a complex activity based on challenging problems that engages students in project design and problem solving and provides opportunities for students to work independently (Fitriyani, 2018). PjBL is an effective learning to develop students' science literacy skills (Tasiwan, 2015). Students who perform PjBL activities will have more significant learning outcomes than those who use regular learning as usual (Çakici, 2013). PjBL provides opportunities for teachers to motivate students to develop the right strategies, design projects and make research in solving real problems faced.

Student-centered learning can make students more critical, investigative, communicative and interactive in conducting experiments (Farida, 2017). PjBL emphasizes the interrelationship between concepts and the child's daily experiences so that students can relate concepts they already have with the new knowledge they have gained. Characteristics of PjBL according to Kosasih (2014), 1) the existence of activities that produce products or works, 2) the concept of learning materials is connected to daily life, 3) learning can be carried out in the classroom or outside the classroom, 4) students design the activities or products produced, 5) assessments are carried out from planning activities, processes to results. Tiantong (2013), in his research, he mentioned that PjBL is effective for improving student learning outcomes. Through project-based learning students can gain more active knowledge, and students are more responsible in the learning process.

The challenge of an educator is to provide an educational system that creates opportunities for learners to connect knowledge and skills. Opportunities will not be created if knowledge and skills are separated in a learning process. Pfeiffer (2013) states that in STEAM learning skills and knowledge are used simultaneously by learners. Students are expected to be able to have the ability to live as individuals and citizens who are faithful, productive, and able to contribute to their lives. STEAM based learning approach that offers meta-disciplinary education in developing thinking skills and creativity in solving problems. STEAM as an integration of the discipline of art into the curriculum and learning in the areas of science, technology, engineering and mathematics (Buonincontro, 2018). STEAM is a meta-discipline in which teachers of science, technology, engineering and mathematics teach an integrated approach and each disciplinary material is not divided but handled and treated as a dynamic whole (Mariale, 2019). Based on the description above, this study aims to develop PjBL with STEAM approach model in improving the science literacy skills of high school students in East Lombok.

Methods

The type of research used Borg & Gall model with steps 1) needs analysis, 2) product design, 3) product development, 4) product implementation and evaluation (Borg & Gall, 2007). The needs analysis was carried out by open interviews with biology teachers and providing questionnaires to students about students' feelings in participating in learning by biology teachers. The interview with the biology teacher related to the learning strategy used consists of 5 questions. The questionnaire about students' feelings after attending the lesson consisted of 15 questions. The test subjects of this study were class X of SMAN 2 Selong, East Lombok with a total of 35 students consisting of 10 male and 25 female who were taken by random sampling.

The research instruments used in this study include 1) guidelines for validation of learning products, 2) guidelines for the practicality of learning implementation, and 3) learning outcomes tests on ecosystem materials. The learning product validation guidelines developed contain measurement indicators, including: 1) indicators of goal formulation, 2) content indicators, 3) indicators of the language used, and 4) indicators of time. Meanwhile, the guidelines for the practicality of implementing the developed product contain indicators of 1) students' feelings of pleasure in the learning process, 2) assessment of the novelty of the product developed in learning, 3) student interest in participating in learning using the developed product. The learning outcomes test instrument on ecosystem materials is an essay test with indicators: 1) explain the facts and concepts, 2) presenting hypotheses, 3) answering questions related to science information. Meanwhile, the product in the form of a learning design that has been developed is validated by 3 experts, namely material experts, learning technology experts, and linguists. To obtain a valid, practical, and effective product, field trials are carried out. The quality of the development product in the form of a learning design PjBL with STEAM approach model is measured based on product validity, product practicality and product effectiveness. Product validation indicators are presented in Table 1.

Table 1. Expert Developed Product Validation Guidelines

Aspects	Indicators
Conformity	The level of conformity of the learning design with the model developed with the basic competencies and indicators of competency achievement in the curriculum
Ease	The language used in developing products with a level of understanding is difficult, moderate or easy by the teacher.
Completeness	Completeness of materials and variations in learning
Clarity	Clarity of description and systematic arrangement of the material in the learning model

The product developed in the form of PjBL with STEAM approach in improving science literacy ability is said to be valid if the product developed is in accordance with each aspect with indicators set for each aspect. The validity criteria of the learning model developed using criteria such as Table 2.

Table 2. Learning Model Validity Criteria

Interval Score	Validity Criteria
$x \geq 85$	Very valid
$70 \leq x < 85$	Valid
$45 \leq x < 70$	Quite Valid
$x < 45$	Less Valid

The practicality of the product developed in the form of a learning design with a PjBL with STEAM approach is tested based on 1) an assessment of the practicality of the product by experts, 2) the magnitude of the teacher's response after carrying out learning with a PjBL with STEAM approach in improving science literacy ability with criteria such as Table 3.

Table 3. Practicality Criteria of Learning Models

Interval Score	Practicality Criteria
$x \geq 85$	Very Practical
$70 \leq x < 85$	Practical
$45 \leq x < 70$	Quite Practical
$x < 45$	Less Practical

Meanwhile, to test the effectiveness of the products developed in improving science literacy ability is carried out by analyzing the scores of science literacy ability test results after getting learning. The indicator of product effectiveness set is that at least 85% of all students who take the ecosystem material learning outcomes test get a minimum score of 75. Meanwhile, to test the potential effects of products that have been developed in improving student learning outcomes, it is carried out by calculating the N-Gain value by calculating the difference between postes scores and pretests of student learning outcomes on ecosystem materials.

Results and Discussion

Needs Analysis

Before conducting research as a basis for developing products, researchers conducted a needs analysis by conducting interviews with biology teachers high school related to the application of the learning strategies used and providing questionnaires to students about students' feelings after participating in biology learning. The results of interviews with 3 biology teachers can be concluded that 1) most of the learning process carried out is still conventional and not student-centered, the teacher's dominance in learning is very high, students' thinking ability has not been developed adequately and the teacher provides more examples and practice questions, 2) In learning, teachers have not carried out variations in learning and have not taken advantage of real problems, 3) In learning, schools need to prepare supporting facilities related to the use of technology and an adequate internet network in integrating technology in learning, 4) Teachers expect support from schools to improve their knowledge of innovative learning as part of the competencies needed in implementing current learning.

Meanwhile, based on the questionnaire given to 35 students of class X Senior High School on the learning carried out by biology teachers, it showed that 1) the learning obtained was generally not fun, boring, and monotonous with a percentage of 75%, 2) in learning, the teacher's efforts to develop students' thinking skills are not optimal so that students are confused when facing non-routine questions, which require the ability to think in solving the problems faced, 3) In learning, teachers and students have not utilized adequate technology as the demands of 21st century learning today because the availability of technology needed in learning in schools is still lacking with a percentage of 80%, 4) In learning, teachers have not used innovative and varied learning strategies so that learning is momoton with a percentage of 75%. Referring to the needs analysis above, is necessary to develop a learning model that is able to develop students' thinking abilities by actively involving students in learning so that two-way interaction in learning can be carried out.

Product Design Stage

The development product is in the form of an integrated PjBL instructional design of science literacy. Products are developed according to the stages of learning activities that refer to the integrated PjBL model of science literacy, namely: 1) starting with important questions, taking topics that correspond to real-world reality and starting with investigations using students' science skills, 2) project work planning, and selection of activities related to science skills in answering important questions, 3) drawing up a schedule of activities, 4) monitor the progress of student projects, 5) assessment of student project outcomes, 6) evaluation of student learning experiences. This step is in line with the research Muskania & Wilujeng (2017) that the learning of the project begins by providing problems that lead to the final product to be produced by the student. After brainstorming, the next step students are given the task of creating and designing projects. During the design of the project, students are directed to search for valid and scientific-like literature and sources. Collaborating with the team during project learning is of utmost importance. Collaboration is one of the characteristics of project learning activities with the aim of helping students to exchange ideas and have good communication skills. Meanwhile, Astawa, (2017) explained that the PjBL stage trains students to become active and creative thinkers and engage in cooperative learning to work together.

Product Development and Evaluation Stage

The product draft developed was validated by 3 experts, namely learning material experts, learning technology experts and learning practitioners. Expert validation is performed to get feedback, suggestions, comments, and corrections to the initial product for further improvement to improve the product. Based on the results of the validity analysis, a product validity score is obtained as presented in Table 4.

Table 4. Validation Results of Developed Products

Component	Validation Results		
	Material Expert	Technologist	Linguist
Identity	92	90	85
Formulation of Indicators	81	79	85
Goal Formulation	85	80	82
Material suitability	80	82	80
Preliminary Activities	80	85	85
Core Activities	82	85	84
Learning Activities	85	87	86
Learning Resources	87	86	85
Evaluation	85	85	82
Closing	84	87	85
Language Use	82	85	82
Average Score	83,91	84,64	83,73
Conclusion	Valid	Valid	Valid

Based on the validation results by experts in Table 4 above, the average product validation scores of the three experts are successively 83.91; 84,64; and 83.73 so that the product developed is classified as valid and suitable for use.

Product Revisions

Although according to experts, the product is PjBL wiith STEAM approach meets the validity criteria and is feasible to continue with field trials, but there are several components that need to be revised according to experts, including: 1) Aspects of indicator formulation, namely the need to use operational verbs C4, C5, and C6 that measure high-level thinking ability, 2) Aspects of learning activities, it is recommended to use various variations in learning so that learning is more interesting, 3) Aspects of language use, it is recommended to use language that is easy for students to understand.

Product Practicality

The practicality of the product developed is tested based on practicality scores by experts and the implementation of learning carried out by teachers in teaching ecosystem materials using previously established practicality criteria. Based on the data obtained from the observation sheets that have been collected both observation sheets by experts and teacher responses, presented as Table 5.

Table 5. Results of the Practicality Assessment of the Developed Model

Validators	Score	Category
Material Expert	82,25	Practical
Technologist	84,14	Practical
Linguist	80,54	Practical
Average	82,31	Practical

Based on the validation results of experts by both the first, second and third experts and the average results from validation show that PjBL with STEAM approach model developed is relatively practical. The practicality of the product based on the implementation of learning carried out by biology teachers using the developed product is presented in Table 6.

Table 6. Results of the Practicality Assessment of the Products Developed

Aspects	Meeting		
	First	Second	Third
Learning Objectives	84	84	85
Motivating Students	85	85	85
Giving real problems	82	84	82
Material Mastery	83	80	82
Guiding students	80	82	82
Application of learning syntax	79	80	80
Classroom Management	82	80	85
Evaluation	80	84	85
Conclusion	82	84	85
Average	81,89	82,56	83,44
Category	Practical	Practical	Practical

Referring to the scores shown in Table 6 above, it shows that, the application of PjBL with STEAM approach model in improving science literacy ability for 3 meetings shows that the learning model used in learning is included in the practical category both at meetings 1, 2, and 3. However, based on the results of observations at each meeting, there are several things that must be improved in the implementation of learning. At the first meeting, the results of the observations showed that the teacher needed to make improvements 1) the teacher needed to provide real problems according to the material being taught, 2) re-examine the sequence of learning syntax so that the implementation of learning was more systematic and follow the syntax that had been formulated in the learning design, 3) in drawing conclusions, it was suggested that the teacher first ask the students to draw conclusions and the teacher directed not the teacher who immediately conclusion. In the second meeting, the results of the observations showed that mastery of learning syntax is still not fully mastered by teachers, this is because the application of PjBL with STEAM approach model in improving science literacy ability tends to be new to teachers and it is recommended that the learning syntax be better understood. At the third meeting, the real problems chosen by the teacher in the initial activity need to be adapted to the material being taught and more challenging which requires various strategies in solving. In addition, teachers need mastery of maateri both essential and advanced materials because this will affect the management of the class carried out by the teacher. In drawing conclusions, the teacher also needs to ask the students to draw conclusions and the teacher provides reinforcement. Based on the data presented above, it can be said that students' science literacy and understanding of students' concepts can be improved by innovating in learning using PjBL with a STEM approach during the learning process (Anggereini, 2023). Hal ini juga sejalan dengan penelitian yang dilakukan oleh Fadlina (2021) yang menyatkan bahwa the innovation of the STEM PjBL model in improving students' scientific literacy students.

Product Effectiveness

The effectiveness of the product developed is PjBL with STEAM approach model as can be seen from the pretest and posttest scores on the ecosystem material. The scores of the pretest results and postest of the students science literacy are shown as in Figure 1.

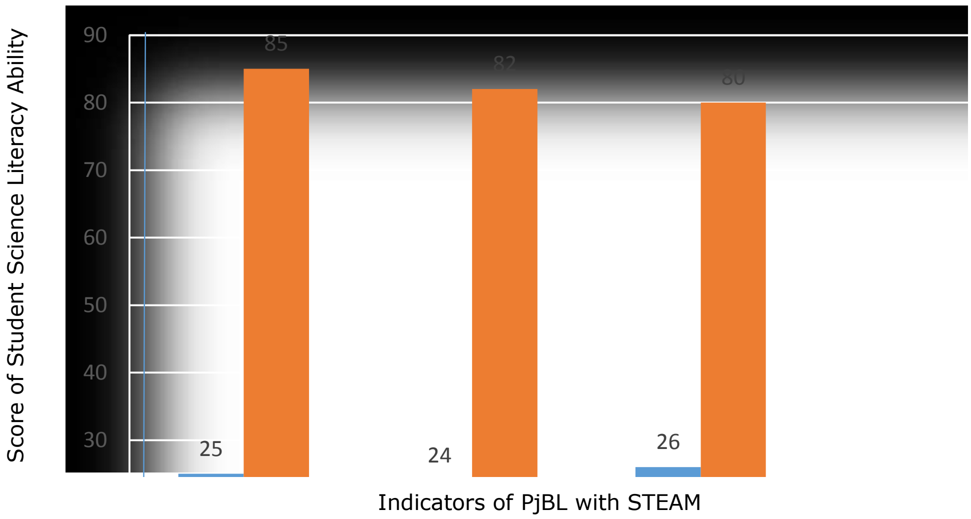

Figure 1. The scores of the pretest and postest of the students science literacy

The test was given to 35 students in class X of Senior High School with average score of the pretest and postest was 26,67 and 81,83 of ecosystem material. Of the 35 class X high school students who were given the test on the ecosystem material, there were 32 students or 91.43% who got a test score of ≥ 75 and only 3 students who did not complete the test score < 75. It can be concluded that the percentage of student completion in learning, which is 91.43%, meets the criteria for the implementation of the product developed, namely the classical score of students after getting learning PjBL with STEAM approach model of least 85%. Thus the product developed is effective to use. The results of this study are in line with those conducted by Putri & Usmeldi (2022) that learning with a STEM approach can increase scientific literacy, because it contains steps that accommodate literacy skills at the time of learning. Similarly, research conducted by Astuti (2023) shows that the STEAM approach can increase students' science literacy and creativity. This is in line with Anekawati (2021) states that science skill process influenced cognitive learning outcome in the learning process using the PjBL model integrated with STEAM, and there was a different influence between the group of students with right and left brain dominance. Meanwhile, Shamdas (2023) states that applying STEAM had a significant effect on high school students' communication skills compared to direct STEM-based learning.

Testing whether the learning model developed has the potential to improve student biology learning outcomes is determined based on the N-Gain value, namely the difference in postes and pretest scores on ecosystem materials after going through trials of applications PjBL with STEAM approach model. Based on the calculation results obtained N-Gain of 0.76 is included in the high category. Based on the foregoing, it can be said that the application of PjBL with STEAM approach model has high potential in improving science literacy ability of the biology of the ecosystem material of high school students. This is in line with the research Fatimah (2018) which explains that PjBL gives students greater opportunities to think and explore their ability to complete tasks and find the right concepts and is significantly able to improve students' science literacy skills. STEM-based project learning was able to increase the average critical and creative thinking skills of students on all indicators that varied from low to moderate categories (Sumarni, 2020).

Learning with PjBL begins with the presentation of important issues and students are asked to play an active role in conveying their ideas and ideas about the material related to it. At the project design stage, students actively discuss conducting experiments, then students present the results of their projects. The series of activities carried out in biology learning with integrated PjBL science literacy is believed to be able to create student curiosity and improve students' science literacy skills. Learning with integrated PjBL science literacy is necessary to be able to provide answers to essential questions, and provide deductive and inductive conclusions on specific problems (Insyasiska, 2015). Research conducted by (Çelik, 2018) states that teachers need to support students to find and discuss solutions by allowing sufficient time. Meanwhile, Ulger (2018) states that in learning teachers can develop students' ideas and The learning of PjBL with STEAM approach model also has a high potential effect in improving science literacy ability as indicated by an N-Gain score of 0.76 in solving the problems encountered in various ways that are found. In this study, the analysis of ecosystem problems was chosen as the main problem to be solved by students. Projects designed by students are solutions to the problems faced, namely ecosystem problems. Students are divided into four groups with each group given the freedom to determine the materials and methods used to conduct an analysis of the ecosystem according to their creativity. PjBL is believed to be able to create curiosity and improve students' science literacy (Nuraini & Waluyo, 2021). The results of this study are in line with the research conducted by Nita (2021) which states that the application of PjBL can improve student learning outcomes and science literacy. Through PjBL with the integration of science literacy, students not only identify problems and find solutions to the problems faced, but students can also use various knowledge and abilities to solve problems (Yamin, 2020). PjBL with the integration of science has also facilitated students to develop themselves both academically and practically to find solutions in everyday life (Husamah, 2015). Meanwhile, Sasson, & Malkinson (2018) in his research stated that PjBL is included in innovative learning that can develop students' science literacy skills. By applying integrated PjBL science literacy in learning, students will be facilitated in developing their science literacy skills in dealing with contextual problems (Chen & Yang, 2019). By implementing integrated PjBL science literacy, students are given the freedom to be more active and express their ideas through the project projects they create (Ririn, 2021). By applying this integrated PjBL literacyscience, learning is not only delivered theoretically but also through direct practice in making works or products in learning (Rohana, 2017) states that learning with PjBL can improve students' literacy skills. Meanwhile, (Gunawan, 2017) states that learning to use projects can increase students' creativity and literacy. Similarly, Afriana (2018) showed that learning with PjBL can improve students' scientific literacy skills.

Integrated PjBL with STEAM approach encourages students to be active and skilled in learning activities and they understand the knowledge that must be possessed through project design and its implementation. Through integrated PjBL with STEAM approach, students can build knowledge through real experiences and experiment with group members and between groups, so that students' science literacy can improve. Through PjBL with STEAM approach, student learning outcomes are better than conventional learning models (Siwa, 2013). PjBL with STEAM approach is useful in designing effective learning so that it has the potential to meet its demands. Integrated science literacy PjBL assists students in 1) strengthening meaningful knowledge and skills built through essential tasks, 2) expanding knowledge through investigation, with results or answers not determined by a particular perspective, and 3) building knowledge through real experiences that take place in a collaborative work atmosphere. This is in line with the research (Wijanarko, 2017) that the PjBL model empowers students' science literacy through scientific work to solve a problem and produce products so that the learning outcomes are maximized. Through hands-on experience allows students to practice using their senses, collect evidence and then follow up by asking questions or formulating hypotheses based on existing ideas so that it has the potential to improve students' science literacy ability.

In the PjBL with STEAM approach, teachers need to provide guidance to each group so that each student uses critical thinking skills, using scientific principles in solving problems. Research conducted by Wolthuis (2020) states that in learning teachers must be able to manage classes well, facilitate students in learning and re-conclude the material taught. PjBL with STEAM approach, allowing students to be given the opportunity to discuss in groups to develop science and science literacy skills. Learning with PjBL has a close relationship with student science literacy, because by using the PjBL learning model students can improve their thinking skills so that students' science literacy can develop (Fitriyani, 2018). PjBL with STEAM approach, encouraging students to reflect on what they have done so that they are aware of its weaknesses and advantages (Murniyati, 2018). This results in improving students' science literacy skills. In line with the research conducted (Hardjo, 2018) that science literacy can equip students with the correct concepts of science and hopefully they can apply them to real life.

Conclusion

The results of the research that has been carried out can be concluded that The PjBL with the STEAM approach model can increase students' science lieration ability as shown by the N-Gain value of 0.76 with a high category. The effectiveness test of PjBL with STEAM approach ecosystem material showed that the score postest of science literacy ability with indicators of the ability to explain the facts, presenting hyphotheses and answering questions with a presentation of 91.43% from 35 students who scored above 75.

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References

Acar, D., Tertemiz, N., & Taşdemir, A. 2018. The effects of STEM training on the academic achievement of 4th graders in science and mathematics and their views on STEM training teachers. *International Electronic Journal of Elementary Education*, 10(4):505–513. https://doi.org/10.26822/iejee.2018438141.

Afriana, J., Permanasari, A., & Fitriani, A. 2018. Penerapan project based learning terintegrasi STEM untuk meningkatkan literasi sains siswa ditinjau dari gender. *Jurnal Inovasi Pendidikan IPA*, 2(2):202–212. https://dx.doi.org/10.15446/revfacmed.v66n3.60060.

Anekawati, A., Hidayat, J., Abdullah, N., & Matlubah, H. 2021. Structural equation modeling multi-group of science process skills and cognitive in pjbl integrated steam learning, *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(3):512-527. https://doi.org/10.24815/jpsi.v9i3.20447.

Anggereini, A. Siburian, J., & Hamidah, A. 2023. Identification of project based learning and STEM PjBL innovation based on socio scientific issues as an effort to improve students' scientific literacy. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1):165-177. https://doi.org/10.24815/jpsi.v11i1.26927

Astawa, N., Artini, L., & Nitiasih, P. 2017. Project based learning activities and EFL students' productive skills in english. *Journal of Language Teaching and Research*, 8(6):1147–1155. https://dx.doi.org/10.17507/jltr.0806.16.

Astuti, W., Sulastri, Syukri, M., & Halim, A. 2023. Implementasi pendekatan science, technology, engieering, and mathematics untuk meningkatkan kemampuan literasi sains dan kreativitas siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1):25-39. https://doi.org/10.24815/jpsi.v11i1. 26646.

Baker, E., Trygg, B., Otto, P., Tudor, M., & Ferguson, L. 2004. Project based learning model: relevant learning for the 21st century. Pacific Education Institute, Washington.

Borg, W.R. & Gall, M. 2007. Education research: An introduction. Longman, New York.

Çakici, Y. & Türkmen, N. 2013. An investigation of the effect of project based learning approach on children's achievement and attitude in science. *The Online Journal of Science and Technology*, 3(2):9–17. https://dergipark.org.tr/en/pub/tojsat/issue/22659/242010.

Çelik, A. & Bukova Güzel, E. 2018. Describing lesson study designed for improvement of mathematics teachers' knowledge of student thinking. *International Journal for Mathematics Teaching and Learning*, 19(2):176–204. https://doi.org/10.29333/iejme/8461.

Chen, C.H. & Yang, Y. 2019. Revisiting the effects of project based learning on students' academicachievement: A meta-analysis investigating moderators. *Educational Research Review*, 26(1):71–81. https://10.1016/j.edurev.2018.11.001.

Durden, G. 2018. Improving teacher learning: Variation in conceptions of learning study. *International Journal for Lesson and Learning Studies*, 7(1):50–61. https://10.1108/ijlls-09-2017-0041.

Fadlina, F., Artika, W., Khairil, K., Nurmaliah, C., & Abdullah, A. 2021. Penerapan model discovery learning berbasis STEM pada materi sistem gerak untuk meningkatkan keterampilan berpikir kritis. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(1):99-107. https://doi.org/10.24815/jpsi.v9i1.18591.

Farida, I., Hadiansah, Mahmud, & Munandar, A. 2017. Project based learning design for internalization of environmental literacy with islamic value. *Journal Pendidikan IPA Indonesia*, 6(2):277–284. https://doi.org/10.15294/jpii.v6i2.9452.

Fatimah, S. & Kartika, C.S. 2018. Project-Based Science Learning And Pre-Service Teachers' Science Literacy Skill And Creative Thinking. *Jurnal Cakrawala*, 7(2):100–115. https://10.21831/cp.v38i3.17229.

Fitriyani, L.O., Koderi, & Anggraini, W. 2018. Project based learning : pengaruhnya terhadap keterampilan proses sains peserta didik di tanggamus. *Indonesian Journal of Science and Mathematics Education*, 1(3):243-253. https://doi.org/10.24042/ijsme.v1i3.3599.

Gunawan, Sahidu, H., Harjono, A., & Suranti, N. 2017. The effect of project based learning with virtual media assistance on student's creativity in physics. *Jurnal Cakrawala Pendidikan*, 36(2):167–179. https://10.21831/cp.v36i2.13514.

Hardjo, F.A. & Permanasari, A. 2018. Pengembangan bahan ajar berbasis proyek pada materi energi untuk meningkatkan literasi sains siswa. *Journal of Science Education and Practice*, 2(1):27–43. https://10.33751/jsep.v2i1.1701.

Harlen, W. 2004. The teaching of science. David Fulton Publisher, London.

Husamah, H. 2015. Thinking skills for environmental sustainability perspective of new students of biology education department through blended project based learning model. *Jurnal Pendidikan IPA Indonesia*, 4(2):110–119. https://doi.org/10.15294/jpii.v4i2.3878.

Insyasiska, D., Siti, Z., & Herawati, S. 2015. Pengaruh project based learning terhadap motivasi belajar. *Jurnal Pendidikan Biologi*, 7(11):9–21. http://dx.doi.org/10.17977/um052v7i1p9-21.

Katz-Buonincontro, J. 2018. Policy, curricular, and programmatic developments in arts-based science, technology, engineering, and mathematics education Introduction. STEAM Focus. *Arts Education Policy Review*, 119(2):73–86. https://doi.org/10.1080/10632913.2017.1407979.

Kilinc, E., Tarman, B. & Aydin, H. 2018. Examining turkish social studies teachers' beliefs about barriers to technology integration. *TechTrends: Linking Research and Practice to Improve Learning*, 6(2):221–233. https://doi.org/10.1007/s11528-018-0280-y.

Kosasih. 2014. Strategi Belajar dan Pembelajaran. Yrama Widya, Jakarta.

Mariale, M., Hardiman, & Ranjini, M. 2019. From STEAM to STEAM : How Can Educator Meet The Challenger ?. *Science Education*, 5(2):1-10 https://doi.org/10.1007/978-3-030-25101-7_1.

Mbhiza, H. 2021. Shifting paradigms: rethinking education during and post-covid-19 pandemic. *Research in Social Sciences and Technology*, 6(2):279-289. https://10.46303/ressat.2021.31.

Movahedzadeh F., Patwell, R., Rieker, J.E., & Gonzalez, T. 2012. Project based learning to promote effective learning in biotechnology courses. *Education Research International ,* 5(2):1–8. https://doi.org/10.1155/2012/536024.

Mullis, M., Martin, O., Pierre, F., & Dana, L. 2019. TIMSS 2019 International Results in Mathematics and Science, Publishers: TIMSS & PIRLS International Study Center, Boston

Murniyati, W. 2018. Perbedaan penerapan model project bsed learning (PJBL) dan problem based learning (PBL) ditinjau dari pencapaian keterampilan proses siswa. *Pancasakti Science Education Journal*, 3(1):25–33. https://10.24905/psej.v3i1.914.

Muskania, R.T. & Wilujeng, I. 2017. Pengembangan perangkat pembelajaran project based learning untuk membekali foundational knowledge dan meningkatkan scientific literacy. *Jurnal Cakrawala Pendidikan*, 36(1):34–43. https://10.21831/cp.v36i1.8830.

Nita, R. & Irwandi, I. 2021. Improving Students' Creative Thinking Ability through Project Based Learning (PjBL) Models. *Bioedusains: Jurnal Pendidikan Biologi dan Sains*, 4(2):231–238. https://doi.org/10.31539/bioedusains.v4i2.2503.

Nunaki, J.H., Damopolii, I., & Kandowangko, N. 2019. The effectiveness of inquiry-based learning to train the students' metacognitive skills based on gender differences. *International Journal of Instruction*, 12(2):505–516. https://doi.org/10.29333/iji.2019.12232a.

Nuraini & Waluyo, E. 2021. Development of instructional design project-based learning model integrated science process skills to improve science literacy. *Jurnal Pendidikan Sains*, 9(1):104–112. https://doi.org/10.26714/jps.9.1.2021.104-112.

OECD. 2016. PISA 2015 Assessment and *analytical framework : science, reading, mathematic and financial literacy*. OEDC Publishing, Paris. http://www.oecd-ilibrary.org/education/pisa-2015

Öztürk, I. 2020. Educational leadership and management: Developing insights and skills. *Educational Policy and Management*, 2(2):133–137. https://10.46303/repam.2020.8.

Pfeiffer, H.D, Ignatov, D.I., & Poelmans, J. 2013. Conceptual Structures for STEM Research and Education. *20th International Conference on Conceptual Structures, Proceedings*. https://link.springer.com/book/10.1007/978-3-642-35786-2.

Putri, M., Afrizal, & Usmeldi. 2022. Metaanalisis efek pendekatan STEM pada literasi sains dan pemahaman konsep peserta didik di setiap satuan pendidikan. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 6(1):86-98. https://doi.org/10.24815/jipi.v6i1.23897.

Ramesh, K. & Duncan, M. 2020. Project based learning in an engineering design course developing mechanical engineering graduates for the world of work. *Science Direct* 9(1):565–570. https://10.1016/j.procir.2020.02.215.

Ririn, P., Wiyanarti, E., & Kurniawati, Y. 2021. The analysis of students' creative thinking skills through the implementation of the project based learning model in social studies learning. *International Journal Pedagogy of Social Studie*, 6(2):9–18. https://doi.org/10.17509/ijposs.v6i2.28622.

Rohana, R.S. & Wati. D. 2017. Project based learning untuk meningkatkan berpikir kreatif siswa SD pada materi makanan dan kesehatan. *Jurnal Penelitian Pendidikan*, 16(3):235–243. https://doi.org/10.17509/jpp.v16i3.4817.

Sasson, I. & Malkinson, N. 2018. Fostering the skills of critical thinking and question-posing in a project-based learning environment. *Thinking Skills and Creativity*, 29(1):203–212. https://10.1016/j.tsc.2018.08.001.

Shamdas, G., Bialangi, M., Buntu, A., & Ihwan. 2023. Application of problem based learning model stem-based on biology lessons for high school students communication skills. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):345-359. https://doi.org/10.24815/jpsi.v11i2.28541.

Siwa, I.B., Muderawan, I.W., & Tika, I. 2013. Pengaruh pembelajaran berbasis proyek dalam pembelajaran kimia terhadap keterampilan proses sains ditinjau dari gaya kognitif siswa. *Journal Program Pascasarjana*, 3(1):1–13. https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ipa/article/view/794/579.

Sumarni, W. & Kadarwati, S. 2020. Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, 9(1):11–21. https//:10.15294/jpii.v9i1.21754.

Tiantong. 2013. The project based learning model on student's multiple intelligency. *Journal of Humanities and Social Science*, 3(7):352–365. https://www.ijhssnet.com/journal/index/1740.

Tsakeni, M. 2021. Transition to online learning by a teacher education program with limited 4IR affordances. *Research in Social Sciences and Technology*, 6(2):129–147. https://doi.org/10.46303/ressat.2021.15.

Ulger, K. 2018. The effect of problem-based learning on the creative thinking and critical thinking disposition of students in visual arts education. *Interdisciplinary Journal of Problem-Based Learning*, 12(1):1–21. https://doi.org/10.7771/1541-5015.1649.

Wijanarko, A.G. & Supardi, K. 2017. Keefektifan model project based learning terbimbing untuk meningkatkan keterampilan proses sains dan hasil belajar IPA. *Journal of Primary Education*, 6(2):120–125. https://10.15294/JPE.V6I2.17561.

Wolthuis, F., Veen, K.V., Vries, S.D., & Hubers, M.D. 2020. Between lethal and local adaptation : Lesson study as an organizational routine. *International Journal of Educational Research*, 100(1):1–12. https://doi.org/10.1016/j.ijer.2020.101534.

Yamin, Y., Permanasari, A., Redjeki, S., & Sopandi. 2020. Implementing project-based learning to enhance creative thinking skills on water pollution topic. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(2):225–232. https://doi.org/10.22219/jpbi.v6i2.12202.

Yanti, M.N., Sudia, M., & Arapu, L. 2019. Pengaruh model pembelajaran mind mapping terhadap kemampuan berpikir kreatif matematis peserta didik kelas VIII SMP Negeri 8 Konawe Selatan. *Jurnal Penelitian Pendidikan Matematika*, 7(3):71–84. http://dx.doi.org/10.36709/jppm.v7i3.11375.

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Validation of Sience, Technology, Engineering, and Matemathic Based Diagnostik Assessment on Natural Resource Material for Phase B Elementary School Students using Rasch Model

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Abstract. One of the ways to design learning the implementation of the independent curriculum is assessment diagnostic. This study aims to develop STEM-based questions to measure students' critical thinking skills. The questions are used for the initial assessment of science subject material "Natural Resources" phase B elementary school. The type of research used is research and development (R&D) with the ADDIE development model, consisting of the analysis, design, developmen, implementation, and evaluation stages. The school students in the city of Semarang with a total of 258 students consisting of 126 male students and 132 female students, using convenience sampling. The items' validation and reliability analysis techniques used the Aiken index and the RASCH model. The results showed that all items had a high validity category based on the following aspects: Outfit items, measure, test difficulty level, person and item reliability. There are several phase bias items, where students in phase C benefit more than students in phase B. The average respon ability is above the averange item difficulty level. The conclusion is that the items developed can be used as initial assessments in science subjects.
Keywords: Assessment Diagnostic, STEM, RASCH Model, Elementary School

Introduction

Learning the new paradigm ensures that the practice of learning is learner-centered (Azis et al., 2022) The new learning paradigm provides educators the flexibility to formulate learning designs and assessments according to the characteristics and needs of students (Phil, 2021). In learning the new paradigm, the learning and assessment cycles are interrelated so that students can achieve the expected competencies. Using appropriate assessments for teachers will determine the weaknesses in learning so that teachers can improve methods in the learning process (Rosnaeni, 2021).

Assessment can be interpreted as comparing or applying measurement results to provide value to the object (Zainal, 2020). Students can carry three aspects of the realm of assessment: knowledge, attitudes, and skills (Jeanne & Prendergast, 2020) Applying diagnostic assessments before designing learning is a hallmark of an independent curriculum. The main direction of learning in the independent curriculum is that students can take advantage of and hone their competencies in their social life (Nurmasyitah et al., 2023). The independent learning curriculum is specifically designed to give the right to learn independently (Inayati, 2022). The independent curriculum is expected to have diverse extracurriculars (Purnawanto, 2022). An independent curriculum makes learning more optimal, giving students enough time to understand concepts and strengthen their competencies.

Based on observations from several elementary schools in the city of Semarang and also as a first step in implementing an independent curriculum, researchers develop an assessment of questions. The questions developed are based STEM. The experience students gain in STEM learning is that students can gain knowledge in science, technology, engineering, and matematics. That knowledge can then be used to solve real-life problems and use them meaningfully in life (Jang et al., 2022). The benefits of implementing STEM education are that it can improve critical and creative thinking skills. In addition, students can be more logically creative, innovative, productive, and directly related to real conditions (Wang & Wang, 2023).

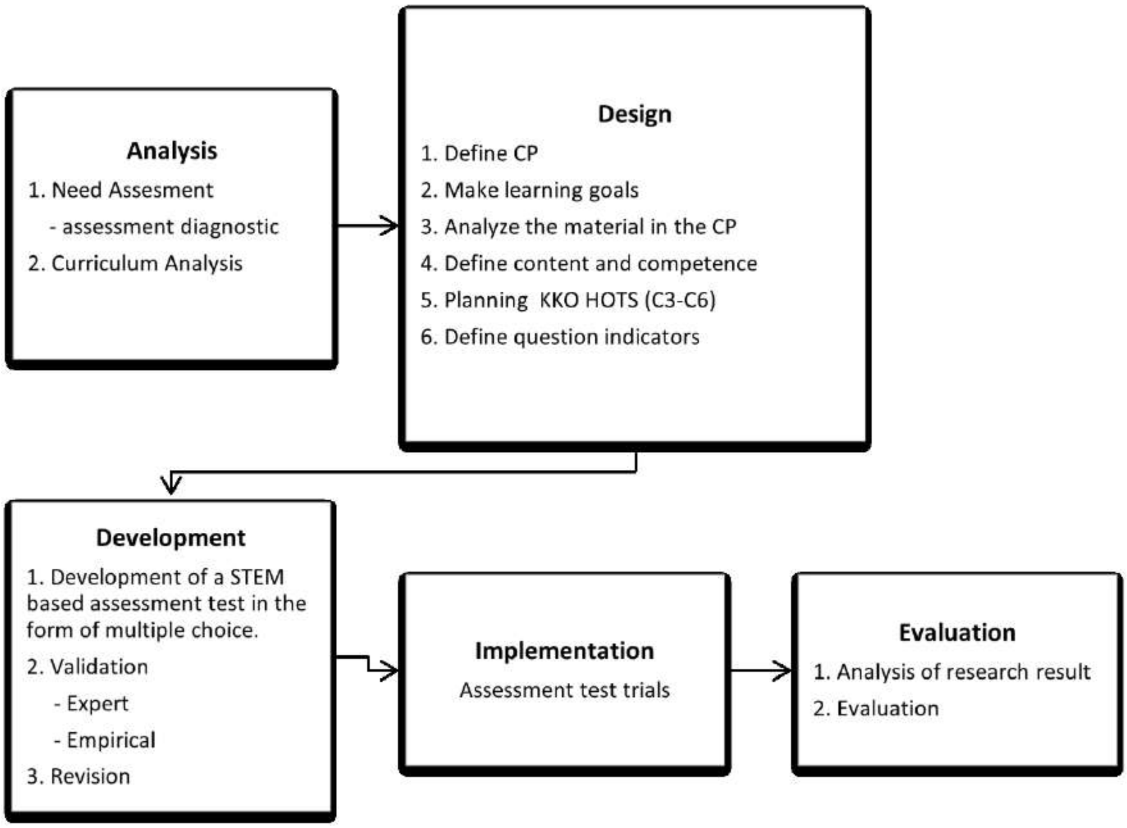
Science is commonly referred to as natural science. Science studies how this universe works, so science can be called a science that studies nature itself. In the 21st century, four skills must be met, namely 1) digital era literacy, 2) inventive thinking, 3) effective communication, and 4) high productivity (Patonah et al., 2020). Scientific literacy is part of literasy which include knowledge and understanding of scientific concepts and processes (Cai-Ting et al., 2020). Science skills are a must-have in the 21st century and can be realized in everyday life. The challenge in learning in the 21st century is integrating pedagogy, technology, and assessment and involving teachers, students, and leaders as stakeholders (Sustiningsih et al., 2021).

Previous research has proven that developing STEM-based test assessment instruments is feasible for measuring students' creative thinking ability (Agustina, 2022). STEM is a modern approach that integrates all of its aspects to solve problems that arise 21st-century life (Hebebci & Usta, 2022). STEM learning aims to solve problems in everyday life by applying it in schools whose learning subjects combine the knowledge, skills, and attitudes students possess (Subayani, 2022).

Applying the right STEM approach model can affect students' success in understanding the material. It can motivate students to find learning concepts (Izzati et al., 2019). Thus, developing this instrument is necessary as an initial assessment of implementing an independent curriculum. This study aims to develop STEM-based questions on natural resource materials for phase B elementary school students as the first step in implementing an independent curriculum.

Methods

This form of research is research and development (R&D). Research and development is a research method used to develop or validate products for teaching and learning (Nugroho & Airlan, 2020). This research was used to develop an assessment test using questions to measure the critical thinking skills of phase B elementary school students on natural resource materials. This research refers to the model developed by Dick and Carry (1996), analysis, design, developmen, implementation, and evaluation (ADDIE) models. The subjects involved in this study were grade III and IV students at SD N in the Semarang city area, with a total of 258 students consisting of 126 male and 132 female students. ADDIE's research and development procedures in detail are shown in flow chart.



The first stage is the analysis stage. Before a diagnostic assessment is developed, a needs analysis and material analysis are first carried out. The analysis was carried out on primary school teachers and elementary school students. At this stage, its activities include collecting information such as teacher needs analysis, student needs analysis, cognitive analysis, and analysis of critical thinking skills. Some of the main things obtained at this stage are 1) implementing STEM-based *diagnostic assessments* has not been applied to phase B natural resource materials, 2) most questions measure aspects of memory that cannot be used to measure students' critical thinking ability.

The second stage is the design or role, carried out after analyzing the existing problem. At this stage, researchers begin to design products to be developed to measure product quality. The activities carried out include 1) determining learning outcomes (LO) based on phases determined based on independent curriculum documents, 2) determining material on learning that has been determined in LO, 3) recognizing competencies and content contained in LO, 4) planning the use of active verbs that are comparable to HOTS questions, starting from C4 to C6 at a predetermined taxonomic level, 5) determine the indicators of the questions, 6) make the question items.

The third stage is the development of the problem. The development product in the form of question items is then validated by experts and practitioners before being tested on students. The product validation results of the question items are revised by expert advice and input. The product of the question item can be implemented if the product has been declared. Validation is carried out through 2 things, namely expert and empirical validation. Expert validation is carried out to review the accuracy of question items that can be seen in terms of material (substance), construction, and language. Seven validator experts, including lecturers and principal practitioners, carry out expert validation. The scores given by the expert use the criteria shown in **Table 1**.

Table 1. Validation Criteria

Grade	Description
5	Highly relevant
4	Relevant
3	Quite Relevant
2	Less Relevant
1	Irrelevant

Analysis data from expert validation was calculated using the Aiken index obtained from seven predetermined validators. The Aiken validity index can be calculated using the formula:

$$s = r\text{-}1 \qquad (1)$$

$$V = \frac{\sum s}{n\,(c-1)} \qquad (2)$$

Remark:
V= rater agreement index regarding validation of question items
r= rater assessment
s= difference of rater reduced by the minimum value of the rater
n= number of appraisers
c= maximum value of validity

Seven experts further validate the questions compiled with the criteria indicated in Table 2.

Table 2. Aiken Index Criteria

Score	Information
>0.4	Low
0.4-0.8	Medium
<0.8	High

Furthermore, the question item is empirically validated. Empirical validation is carried out to test the accuracy of question items and the reliability of instruments based on trials of samples determined in the study (Setemen, 2018). The question item validation test was carried out using the RASCH model with the help of the Winstep 3.73 application. The criteria used to check the suitability of the question item so that it can be said to be appropriate or inappropriate are by looking at the values of outfit mean square (MNSQ), Outfit Z-standard (ZSTD) and point measure correlation (Pt Mean Core). The criteria for items said to be valid can be seen in Table 3 (Arnold et al., 2018; Ramadhani & Fitri, 2020; Sumintono & Widhiarso, 2015).

Table 3. Question Item Validation Criteria

Criteria	Koefisien	Value
Outfit MNSQ	0,5< MNSQ <1,5	Accepted/Valid
Outfit ZSTD	-2,0< ZSTD <+2.0	Accepted/Valid
Pt. Mean Core	0,4< Pt.Mean Core <0,85	Accepted/Valid

The fourth stage is the implementation stage: implementing a diagnostic assessment to be tested on elementary school students. The student in Phase B in the independent curriculum (source) in 2 elementary schools in Semarang City using convenient sampling techniques. Item questions were tested in 2 elementary schools in Semarang city in grades 3 and 4. *A* STEM-based assessment test on natural resource materials was tested on 258 students with different abilities. Trials were conducted to determine the extent to which the level of question items can achieve the desired goal. The quality of the question items developed will be tested empirically through trials.

The last stage is the evaluation stage. In this stage, the question items that have been tested are then analyzed using the Winstep 3.73 application. Each question item is analyzed based on reliability, validity, difficulty level, and bias on certain variables.

Results and Discussion

The *assessment test* instrument developed is an elaboration of each predetermined learning outcome. The elaboration of learning outcomes produces learning objectives to be used as a reference for making questions. Problem indicators are based on content (material) aspects, competency aspects, and taxonomic levels. Each indicator created is then divided into two questions with different taxonomic levels. The taxonomic level for STEM is C4 to C6 because it is indicated by a question with a high level of intelligence (Damanik & Irfandi, 2021; Khaldun et al., 2020; Kristanto & Setiawan, 2020; Ndiung & Jediut, 2020; Widarta & Artika, 2021; Yuliandini et al., 2019). Any question containing STEM can measure students' critical thinking ability.

Based on predetermined learning outcomes produces three learning objectives. The learning objectives were developed into 7 question indicators. Each question indicator compiled two questions according to the level of taxonomy bloom Table 4.

Table 4. The learning outcomes elaboration matrix becomes a problem indicator

Learning Outcomes	Objective Learning	Question Indicator	Order of Question	Key Answer
Learners can identify problems related to the preservation of natural resources in the surrounding environment	Students can conclude the utilization of natural resources in the surrounding environment.	Presented in a case, students can conclude human activities as an effort to preserve living things	1	C
			2	A
		Presented statements, learners can conclude the role of alternative energy in Preservation Efforts	11	B
			12	A

Learning Outcomes	Objective Learning	Question Indicator	Order of Question	Key Answer
and their relation to efforts to conserve living things		Living things		
		Presented with questions, students can conclude the benefits of alternative energy for the preservation of living things	13	B
			14	A
	Students can relate efforts to preserve living things in the surrounding environment	Presented with questions, students can conclude human activities as an effort to preserve living things	3	D
			4	C
		Presented a picture, students can conclude the activities of preserving living beings	7	B
			8	B
		Presented pictures, students can deduce activities that undermine the sustainability Living things	9	A
			10	C
	Learners can diagnose the reasons for efforts to preserve living things.	Presented some efforts to preserve living beings, students can diagnose the reason for the effort that Done	5	A
			6	A

The results of the analysis of question items by expert experts calculated using the Aiken Index are shown in Table 5.

Table 5. Expert Validation Aiken Index

Question	Indeks Aiken		
	A	B	C
1	0.85	0.85	0.84
2	0.85	0.82	0.82
3	0.86	0.83	0.82
4	0.86	0.77	0.82
5	0.84	0.78	0.82
6	0.82	0.78	0.82
7	0.82	0.82	0.80
8	0.83	0.77	0.80
9	0.83	0.80	0.80
10	0.84	0.80	0.80
11	0.79	0.80	0.79
12	0.79	0.80	0.79
13	0.82	0.82	0.81
14	0.83	0.80	0.78

Based on the Aiken Index table validated by expert validators, column A is the result of validation based on the material (substance), column B is the result of validation based on construction, and column C is the result of validation based on language. The study results showed that out of 14 STEM-based questions on natural resource materials for phase B students, they showed good validation based on the validity criteria, the value stated in the "valid" category (>0.4) (Azhar et al., 2020). The values obtained are 0.77-0.86 regarding material, construction, and language. The validity test of items used to determine the cause of the question have low criteria (Wulandari et al., 2022).

After being validated, there are several suggestions for improvement from expert experts, namely the formulation of the subject matter that is not clear and clear, spelling improvements, and the use of appropriate EYD in the question item. Furthermore, improvements were made by formulating the subject matter clearly and clearly and using Indonesian properly and correctly according to the appropriate spelling and EYD.

In the next stage, 14 questions were developed and tested on elementary school students with 258 respondents, 126 men, and 132 women. It aims to determine the suitability of the model (question validity, difficulty level of the question, and reliability of the question). The questions developed were tested in 2 elementary schools in Semarang. Table 6 shows a summary of the data analysis results with the Winstep application's help.

Table 6. Summary Statistic

	Aspect	Value
Model Eror	Person	0.87
	Item	0.15
Reliabilitas	Person Reliability	0.68
	Item Reliability	0.89
	Alpha Cronbach	0.81

In the RASCH model, the difference in power value can be seen from the error standard. Niliai model SE > 0.5 identifies that the different power of the item is good. In the SE model, 0.5-1, the difference power is categorized as quite capable of distinguishing. In the SE model < 1, the difference power is inadequate or unable to distinguish (Purniasari et al., 2021). Based on the results of the research conducted, it shows that the SE items identify that the differential power of the items is good. Meanwhile, the SE person identified that the discriminating power generated was quite capable of discriminating.

Table 6 shows that the criteria of person reliability are sufficient, item reliability is good, and Cronbach's alpha value is good. The criteria are obtained from the view (Sumintono & Widhiarso, 2015) that in determining *item* reliability and *person reliability* based on the following values: <0.67 (weak); 0.67-0.80 (sufficient); 0.81-0.90 (good); 0.91-0.94 (very good); >0.94 (unique). This value shows that the quality of the question items shows excellent results with good reliability, while the quality of human resources is in the category of sufficient. In addition, the value of alpha Cronbach indicates that the interaction between a person and an item as a whole is a good value. Reliability test was carried out using the cronbach alpha formula with criteria of 0.6 (Tursinawati & Widodo, 2019). On the value of reliability ar internal coefficient > 0.7 indicates the questionnaire used is reliable (Puspita et al., 2021).

Table 7. Item Measure

Nomor Soal	Measure	Model S. E.	INFIT		OUTFIT		PT-Measure Corr
			MNSQ	ZSTD	MNSQ	ZSTD	
1	-0.06	0.15	0.90	-1.9	0.94	-0.8	0.55
2	0.35	0.15	0.98	-0.4	0.98	-0.2	0.57
3	0.45	0.15	1.09	1.8	1.11	1.3	0.54
4	-0.42	0.16	0.92	-1.4	0.89	-1.3	0.51
5	0.12	0.15	0.92	-1.5	0.89	-1.5	0.57
6	0.42	0.15	1.02	0.5	0.99	0.0	0.57
7	0.31	0.15	1.02	0.3	1.00	0.0	0.55
8	-0.82	0.16	1.12	1.7	1.17	1.6	0.38
9	0.69	0.16	0.94	-1.0	1.03	0.4	0.62
10	-0.56	0.16	1.02	0.4	1.11	1.2	0.45
11	-0.09	0.15	1.01	O.3	1.06	0.8	0.51
12	-0.46	0.16	0.89	-1.8	0.86	-1.7	0.52
13	0.66	0.16	1.06	1.1	1.14	1.5	0.57
14	-0.59	0.16	1.03	0.5	1.03	0.4	0.45

Table 7 summarizes the RASCH analysis of the Winstep 3.73 application-assisted model, data obtained from 258 respondents and 14 question items. Based on the measured value obtained, seven questions with the difficult item category, and seven with the easy item category. The difficulty level of the question items is reviewed according to (Sumintono & Widhiarso, 2015: 70), which is grouped into four categories, namely < -1 (specific items); -1 to 0 (easy items); 0 to 1 (difficult items); >1 (complicated items).

The analysis results of the problem instruments developed to show that they are valid. This is confused with the MNSQ infit value in the data analysis results, which shows 1.12 ± 0.89. the match conditions can be seen if the MNSQ INFIT value is 0.77-1.33 (Suparman, 2020). Thus it can be concluded that the STEM-based question instrument developed has been valid. The outfit mean squared (outfit MNSQ) value of 0.86 to 1.17 indicates the fit criteria. The match provision is between 0.5<MNSQ<1.5. The test instruments are appropriate to measure students' ability to think critically about natural resource materials.

The distribution of the question item is considered a misfit or unfit if it meets one or both of the following conditions. The first condition is that the MNSQ outfit value value is between 0.5 and 1.5; ZSTD Outfit values are between -2.0 and 2.0; and the item correlation value with a total score point measure correlation located between 0.4 to 0.85 (Sumintono & Widhiarso, 2014). Testing the validity of question items using Pt. measure corr values, with valid criteria if they meet the range of 0.4<Pt. Mean Corr<0.85. So it means there is a polarity item because the value obtained does not meet the required criteria range (Ramadhani & Fitri, 2020). In question item number 8 with the value of Pt. Mean Corr is 0.38. It is stated as an invalid question. While the MNSQ and ZSTD outfit values in Table 7. indicate values of 0.86-1.17 and -1.7-1.6 which means that the item of the developed question is valid or accepted.

Items and measurement instruments that are biased if an item is more partial to one individual with specific characteristics and on the other side of an individual with an opposition character are harmed. The bias of a test can be interpreted as invalidity or sistematic error in measuring members of a group under study (Darmana et al., 2021). A question item is considered biased if the probability value is below 5% (0.05) (Burhani et al., 2022). Based on Figure 1 and Figure 2 shows the level of distribution in answering questions based on gender and phase.

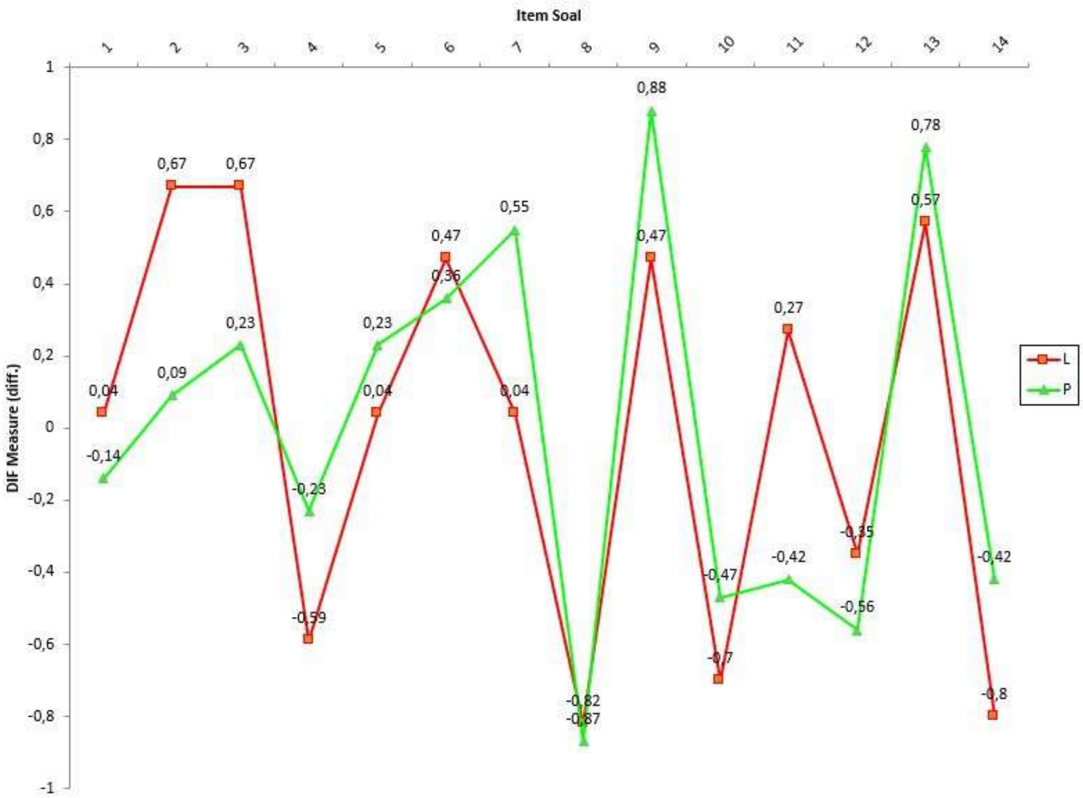


Figure 1. DIF significant level graph by gender

Based on Figure 1, it can be seen the distribution of the difficulty level of the question by gender. The test takers consisted of two different groups, namely the male and female groups. Character identification needs to be done because it can affect the achievement of learning outcomes. The differential item functioning (DIF) value is used to find the instrument's bias. Figure 1 shows that male and female students have no bias and have an average ability not to answer questions well in doing the tested questions.

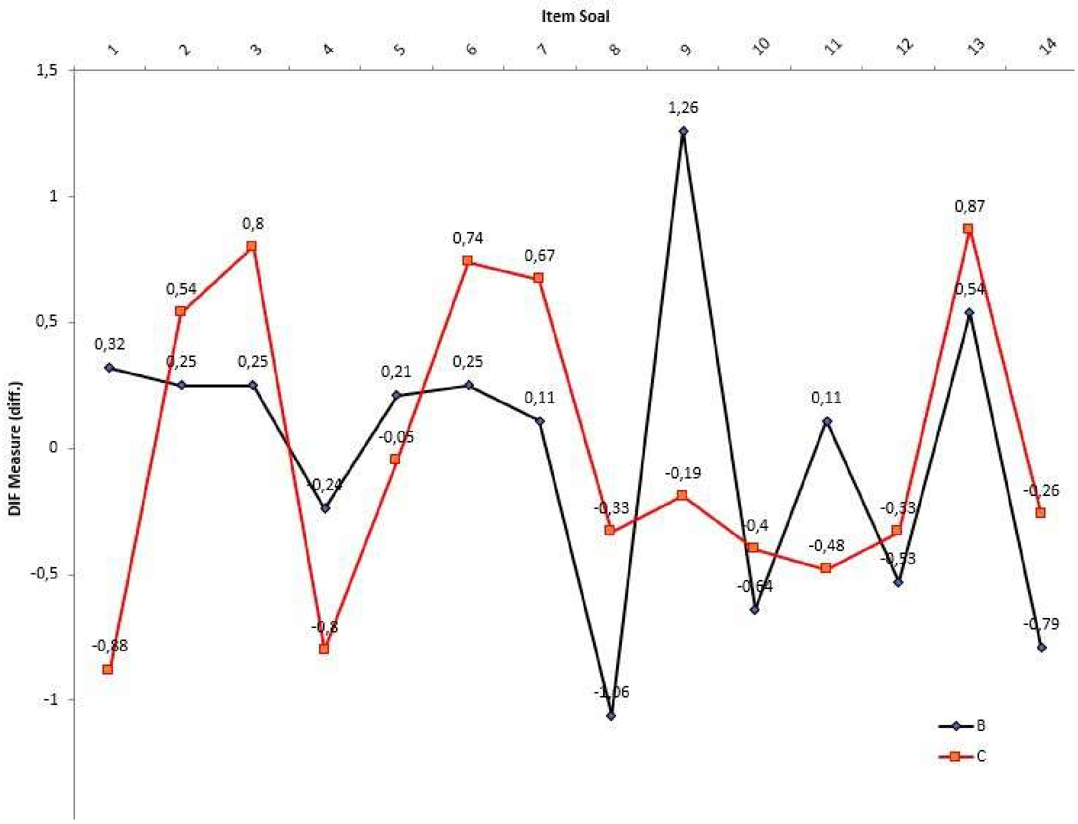


Figure 2. DIF significance level graph by phase

Based on Figure 2, it can be seen that the questions that experience bias (DIF) are questions number 1 and 9. The problem is infected with DIF because the probability value is below 0.05. it can be seen in the graph that the question item is easier for phase C students to do than for phase B students. Meanwhile, a curve close to the upper limit shows a question item with a great difficulty level (question number 9) (Aprilia et al., 2020).

Conclusion

The research produced 14 stem-based questions on natural resource materials for phase B elementary school students with good quality. This development is used as an initial assessment in implementing an independent curriculum to measure students' critical thinking skills. Question items is carried out with two kinds of validation: 1) validation was carried out by seven validator experts with the acquisition of expert material, construction, and language using the Aiken index, 2) empirical validation performed by RASCH modeling using the help of Winstep 3.73 applications. Produce valid question items so that they can be used to measure students' critical thinking skills in phase B for science subjects. Further research can be done to determine the effectiveness of the questions in determining the map of students' abilities so that it can be used as a reference to carry out differentiated learning in elementary schools.

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References

Aprilia, N., Susilaningsih, E., Priatmoko, S., & Kasmui. 2020. Desain instrumen tes pemahaman konsep berbasis hot dengan analisis model rasch. *Chemistry in Education*, 9(2):1–8. https://journal.unnes.ac.id/sju/index.php/chemined.

Arnold, J.C., Boone, W.J., Kremer, K., & Mayer, J. 2018. Assessment of competencies in scientific inquiry through the application of rasch measurement techniques. *Education Sciences*, 8(4): https://doi.org/10.3390/educsci8040184.

Azhar, H., Fisika, P., Tarbiyah, F., Uin, K., & Makassar, A. 2020. Pengembangan media pembelajaran majalah mitigasi angin puting beliung terinterkoneksi ayat-ayat al-qur'an dalam pembelajaran fisika. *Jurnal Pendidikan Fisika*, 8(2):2355–5785. http://journal.uin-alauddin.ac.id/indeks.php/PendidikanFisika.

Azis, F., Kaharuddin, K., Arifin, J., Yumriani, Y., Nawir, M., Nursalam, N., Quraisy, H., Rosa, I., Nuramal, N., & Karlina, Y. 2022. Pendampingan penguatan model pembelajaran paradigma baru bagi guru-guru sekolah muhammadiyah di kecamatan bontonompo selatan. *Jurnal Abdimas Indonesia*, 2(4):515–523. https://doi.org/10.53769/jai.v2i4.337.

Burhani, S.N., Hakim, A., Hadisaputra, S., & Burhanudin. 2022. Analisis media pembelajaran phet simulations berbasis laboratorium virtual terhadap minat belajar kimia selama masa pandemi covid-19. *Chemistry in Education,* 5(2):194-201. https://jurnalfkip.unram.ac.id/index.php/CEP/article/view/3062/2727.

Cai-Ting, W., Liu, C.C., Chang, H.Y., Chang, C.-J., Chang, M.H., Chiang, S.H.F., Yang, C.W., & Hwang, F.K. 2020. Simulation and its relation to school science achievement and scientific literacy. *Komouter & Education*, *149*. https://doi.org/https://doi.org/10.1016/j.compedu.2020.10383

Damanik, F.C. & Irfandi. 2021. Pengembangan instrumen tes berbasis higher order thinking skill (HOTS) bentuk pilihan ganda berdasarkan taksonomi bloom revisi pada materi gelombang bunyi. *Jurnal Inovasi Pembelajaran Fisika*, 10(1):14–20. http://jurnal.unimed.ac.id/2012/index.php/inpafi.

Darmana, A., Sutiani, A., Nasution, H.A., Ismanisa, I., & Nurhaswinda, N. 2021. Analysis of rasch model for the validation of chemistry national exam instruments. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(3):329–345. https://doi.org/10.24815/jpsi.v9i3.19618

Hebebci, M.T. & Usta, E. 2022. The effects of integrated STEM education practices on problem solving skills, scientific creativity, and critical thinking dispositions.

Participatory Educational Research, 9(6):358–379. https://doi.org/10.17275/per.22.143.9.6

Inayati, U. 2022. Konsep dan implementasi kurikulum merdeka pada pembelajaran abad 21 di SD/MI. *ICIE (Internasional Conference on Islamic Education)*, 2(8.5.2017):293–304. http://proceeding.iainkudus.ac.id/index.php/ICIE.

Jeanne, H.S. & Prendergast, C.O. 2020. The assessment skills framework: a taxonomy of assessment knowledge, skills and attitudes authors. *Journal of Research and Practice in Assesment*, 15(1):1–25. https://eric.ed.gov/?id=EJ1269869.

Khaldun, I., Hanum, L., & Utami, S.D. 2020. Pengembangan soal kimia higher order thinking skills berbasis komputer dengan wondershare quiz creator materi hidrolisis garam dan larutan penyangga. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 7(2):132–142. https://doi.org/10.24815/jpsi.v7i2.14702

Kristanto, P.D. & Setiawan, P.G.F. 2020. Pengembangan soal hots (higher order thinking skills) terkait dengan konteks pedesaan. *Prisma: Prosiding Seminar Nasional Matematika*, 3:370–376. http://journal.unnes.ac.id/sju/index.php/prisma/

Ndiung, S. & Jediut, M. 2020. Pengembangan instrumen tes hasil belajar matematika peserta didik sekolah dasar berorientasi pada berpikir tingkat tinggi. *Premiere Educandum : Jurnal Pendidikan Dasar dan Pembelajaran*, 10(1):94-99. https://doi.org/10.25273/pe.v10i1.6274

Nugroho, A.N. & Airlan, A.S. 2020. Pengembangan instrumen penilaian keterampilan berpikir kritis pembelajaran IPA Kelas 4 SD. *Junal Ilmiah Pendidikan Profesi Guru*, 3(3):400-407. https://dx.doi.org/10.23887/jippg.v3i3.

Nurmasyitah, P., Salim, A., Fransiska, I., Daris, K., & Suryani, K. 2023. *Implementation merdeka curriculum of learning to students' learning activities*, 3(1):39–44. https://doi.org/10.30596/jcositte.v1i1.xxxx

Patonah, S., Nuvitalia, D., Saptaningrum, E., & Wuryandini, E. 2020. Inquiry learning tools to train science process skills at the junior high school level. *JPPS (Jurnal Penelitian Pendidikan Sains)*, 9(2):1812–1818. https://doi.org/10.26740/jpps.v9n2.p1812-1818

Phil, S.M. 2021. *Pembelajaran dan Asesmen Kompetensi*. Badan Penelitian dan Pengembangan dan Perbukuan, Jakarta.

Purnawanto, A.T. 2020. Perencanakan pembelajaran bermakna dan asesmen kurikulum merdeka. *Jurnal Ilmiah Pedagogy*, 20(1):75-94. http://www.jurnal.staimuhblora.ac.id/index.php/pedagogy/article/view/116

Purniasari, L., Masykuri, M., & Ariani, S.R.D. 2021. Analisis butir soal ujian sekolah mata pelajaran kimia SMA N 1 kutowinangun tahun pelajaran 2019/2020 menggunakan model iteman dan rasch. *Jurnal Pendidikan Kimia*, 10(2):205–214. https://jurnal.uns.ac.id/jpkim.

Puspita, K., Nazar, M., Hanum, L., & Reza, M. 2021. Pengembangan E-modul Praktikum Kimia Dasar Menggunakan Aplikasi Canva Design. *JIPI (Jurnal IPA & Pembelajaran*

IPA), 5(2):151–161. https://doi.org/10.24815/jipi.v5i2.20334

Ramadhani, R. & Fitri, Y. 2020. Validitas e-modul matematika berbasis epub3 menggunakan analisis rasch model. *Jurnal Gantang*, 5(2):95–111. https://doi.org/10. 31629/jg.v5i2.2535.

Rosnaeni, R. 2021. Karakteristik dan asesmen pembelajaran abad 21. *Jurnal Basicedu*, 5(5):4341–4350. https://doi.org/10.31004/basicedu.v5i5.1548.

Setemen, K. 2018. Pengembangan dan pengujian validitas butir instrumen kecerdasan logis-matematis. *Jurnal Pendidikan Teknologi dan Kejuruan*, 15(2):178-187. https://ejournal.undiksha.ac.id/index.php/JPTK/article/view/14197/9437.

Subayani, N.W. 2022. Implementasi STEM (science, technology, engineering, and mathematics) dalam kurikulum PGSD. *Didaktika : Jurnal Pemikiran Pendidikan*, 28(2):42-49. https://doi.org/10.30587/didaktika.v28i2.4435.

Sumintono, B. & Widhiarso, W. 2014. *Aplikasi Model Rasch Untuk Penelitian Ilmu-Ilmu Sosial*. Trim Komunikata Pubishing House, Cimahi.

Sumintono, B. & Widhiarso, W. 2015. *Aplikasi Pemodelan Rasch Pada Assessment Pendidikan*. Trim Komunikata Pubishing House, Cimahi

Suparman. 2020. Menemukan karakteristik butir menggunakan quest*. Jurnal Komunkasi dan Pendidikan Islam,* 9(1):83–104. https://doi.org/10.36668/jal.v9i1.134.

Sustiningsih, Utaminingsih, S., & Santoso. 2021. Development of science teaching materials based on stem: a needs analysis. *Journal of Physics: Conference Series*, 1823(1). https://doi.org/10.1088/1742-6596/1823/1/012081.

Tursinawati, T. & Widodo, A. 2019. Pemahaman Nature of Science (NoS) Di Era Digital: Perspektif Dari Mahasiswa PGSD. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 3(1):1–9. https://doi.org/10.24815/jipi.v3i1.13294

Wang, J.C. & Wang, T.H. 2023. Learning effectiveness of energy education in junior high schools: Implementation of action research and the predict–observe–explain model to STEM course. *Heliyon*, 9(3):e14058. https://doi.org/10.1016/j.heliyon.2023.e14058.

Widarta, F.O. & Artika, W. 2021. Analisis bentuk stimulus, dimensi kognitif, dan karakteristik HOTS pada instrumen evaluasi mata pelajaran IPA karya guru. *JIPI (Jurnal IPA & Pembelajaran IPA)*, 5(3):197–208. https://doi.org/10.24815/jipi.v5i3. 21429

Wulandari, T., Ramli, M., & Muzzazinah, M. 2022. Analisis butir soal dynamic assessment untuk mengukur pemahaman konsep klasifikasi tumbuhan pada mahasiswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 10(1):191–201. https://doi.org/10.24815/jpsi.v10i1.22082

Yuliandini, N., Hamdu, G., & Respati, R. 2019. Pengembangan soal tes berbasis higher order thinking skill (HOTS) taksonomi bloom revisi di sekolah dasar. *Pedadidaktika: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, 6(1):37–46. http://ejournal.upi.edu/ index.php/pedadidaktita/index.

Zainal, N.F. 2020. Pengukuran, assessment dan evaluasi dalam pembelajaran matematika. *Laplace : Jurnal Pendidikan Matematika*, 3(1):8–26. https://doi.org/10.31537/laplace.v3i1.310.

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Developing Elementary School Student's Learning Independence by using Android-Based Gravity e-comic

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Abstract. Student learning independence is currently low, this is indicated by the lack of a variety of learning media used by teachers. The problem to be raised is that students are not independent in exploring their knowledge, including in science subjects (results from interviews with teachers at SDN 80 Kota Tengah). To overcome these problems, the purpose of this study is to develop an android-based gravity e-comic to increase student learning independence. The method used in this research is the R & D (research & development) method, the development model used to produce android-based gravity e-comics is four d, with steps namely define, design, development, disseminate. Thedata collection procedure is to describe the validity, practicality and effectiveness of the e-comics that are made. Data analysis uses analysis of validity, practicality, and effectiveness. The results showed that the gravity e-comic developed was valid, received positive responses from students and was very good for training the learning independence of elementary school students, so it was feasible to use in the science learning process in elementary school. The conclusion of this study is that android-based gravity e-comics are valid, practical to use in the learning process, and effective in increasing student learning independence at the elementary school level.
Keywords: e-comic, gravity, independence.

Introduction

The learning process is a transferring information sourced from the provider to the receiver (Huda, 2013). Therefore, the use of learning media occupies an important position as one of the components in the learning process (Putri & Ariyanti, 2015). Learning media can be used to convey messages and stimulate a meaning full learning process, because learning media is broader than teaching aids, teaching aids, and audio-visual media (Zainal, 2013; Astutietal,2019).

The selection of learning media that is interesting for students can optimize the learning process, where one of the learning media that is interesting for students is comics. According to Nurgiyantoro (2013) comics are stories displayed through pictures in panels accompanied by balloons containing written text. The use of interesting images by presenting events chronologically is the uniqueness of comics as learning media, the same thing was stated by Awiegerova & Navratilova (2017) who revealed that the use of comics that link a scene with students daily lives and the use of simple language can help students to learn the material students can.

The uniqueness of this comic can be an opportunity for teachers, especially for teaching science material for elementary school children, where elementary school children really like pictures, in other hand, learning science comics can be used to explain abstract concepts (Akcanca, 2020; Ilhan & Oruc, 2019). The results showed that comics are feasible to use in the learning process because they can improve student learning outcomes (Yulianti, et al., 2018;Yulinda, et.al., 2019). In addition, comics are very useful to use as a learning medium that motivates students to learn through the images and text presented (Koutnikova, 2015), where by reading comics students are more relaxed in thinking, increasing students' imagination in finding their own ideas (Wang, 2022). This is in line with the opinion of Nurohim et al. (2012), which states that comics can increase student learning motivation through visualization of abstract science material, and can be printed according to student needs. Compared to using textbooks, the use of comics as learning media can improve students cognitive abilities (Avrillianti et al., 2013; Casumpang & Enteria, 2019).

The development of science and technology, the utilization of android-based learning media is one of the solutions to current educational problems. Nazar, et al. (2020) explain that android-based learning application scan be used as media in learning, by utilizing technology in the learning process can make students more interested in learning topics (Papadakis, 2020) and students also respond positively to the use of technology in the learning process (Lisnani & Emmanuel, 2020). Therefore, android-based comics is a challenge in their own development, several researchers have developed android-based comic media or commonly called e-comics. According to Buchori & Setyawati (2015), e-comic is a reading that allows students to use online media on the internet, intranet, or other computer network media. The use of e-comics can improve the quality of learning and student learning outcomes (Riwanto & Budiarti, 2020; Wicaksono et al., 2021; Damopolii et al., 2021).

The learning process should not only improve students' cognitive learning outcomes, but also pay attention to affective aspects. In this case, the character of students, including the character of independence, where independence is important in a learning process because being independent in the learning process will affect student achievement (Rahmayani, 2019).

The results of Ariah's research (2015) show that student independence is currently fairly low, this is indicated by the number of students who can not be independent in doing school assignments. This is supported by the results of interviews with teachers at SDN 80 Kota Tengah who said that students are not independent in exploring their knowledge, including for gaya material, this is indicated to be caused by the lack of learning media suitable for elementary school children. This needs attention considering that there is a positive although low relationship between learning independence and learning outcomes (Permata et al., 2022). Although, according to Elistiani (2022) there is no significant relationship between student learning independence and student science test results.

In the learning process, most teachers use textbooks to teach material in class, so it does not support the creation of learning independence for students. This will certainly have an impact on students' daily lives, where students will depend on others to be able to solve their life problems. Independence is defined as a condition of not depending on others in making decisions and having a confident attitude, while learning independence is defined as the ability of children to believe in their own abilities, the ability to learn independently and not easily depend on others (Wuryandani et al., 2016).

The use of comics as a learning media is one of the solutions to increase students learning independence, where this learning independence can be in still led in students from an early age, through the use of comics as a learning media, as revealed by Wibowo & Koeswanti (2021) that comics can increase student learning independence in elementary schools. The purpose of this research is to produce android-based gravity e-comics that can increase the independence of students in elementary schools.

Methods

The method used in this research is the R & D (research and development) method. According to (Nana, 2016), development research is a study that aims to develop an existing product or produce a new product that can be accounted for. This research produces a new product, namely android-based gravity e-comics for elementary school students. Data collection procedures by describing the validity, practicality and effectiveness of the e-comics that are made. The data collection technique is through instruments in the form of questionnaires and learning achievement tests. Data analysis uses analysis of validity, practicality, and effectiveness. The development model used to produce the android-based gravity is comic four d. The development steps are carried out based on four stages, namely define, design, develop, disseminate. To measure the quality of the android-based gravity e-comic produced, researchers refer to the opinion of Akker (1999) and Nieveen (1999) who suggest that the quality of a product is seen from the level of validity, practicality and effectiveness of the product produced.

The validity of the android-based gravity e-comic is shown by the results of validation through a validation sheet conducted by 4 experts, namely two science learning experts and 2 learning media experts. The practicality of the product is shown by student responses to the use of android-based gravitye-comics and the effectiveness of the product is shown by an increase in student learning independence.

To obtain data on the practicality and effectiveness of android-based Gravitye-comics, this research was conducted at SDN 80 Kota Tengah Gorontalo City in the odd semester of the 2022/2023 academic year. The research subjects for the development stage were 15 students in class VA and 25 students in class VB.

Student response as an indicator of the practicality of the android-based Gravity e-comic is measured using a student response questionnaire, while learning independence as an indicator of the effectiveness of the android-based Gravity e-comic is measured using a learning independence questionnaire.

Data analysis for this study was carried out to analyze data on the validity of practicality in this case student responses and effectiveness in this case student learning independence, as described. The validity analysis was carried out by calculating the average assessment of each expert. Furthermore, to determine the criteria for validation results refer to Table 1.

Table 1. The criteria for validation results

No.	Value Range	Criteria for Validation
1	4.00 – 3.75	Very Valid
2	3.75 – 3.00	Valid
3	3.00 – 2.25	Fairly Valid
4	2.25 – 1.50	Less Valid

(source: Arikunto, 2013)

If the validation results are on valid or very valid criteria, then the android-based Gravitye-comic can be used in the limited trial and implementation stages to determine student response and learning independence.
Data analysis for student responses and student learning independence is carried out with the following steps. The answer options for the response questionnaire and students' learning independence are yes and no. Yes answer options for positive student responses were given a value of 1, while no answer options for negative student responses were given a value of zero.

After the data for all students was collected, this data was then analyzed using the equation: $NP = \frac{R}{SM}$ (1)

NP = presentation score
R= score obtained
SM = Maximum score of the expected aspect (Widoyoko, 2012)

The percentage value is categorized base on

Table 2. Response criteria and student learning independence

No	Response criteria (%)	Category
1	86–100	Very Good
2	75–85	Good
3	66–74	Fair

(source: Arikunto, 2013)

If the results of the analysis of student responses and learning independence are in the good and very good categories, then the android-based gravity e-comic can be used in a more widespread learning process.

Results and Discussion

The result of the research is the availability of an android-based gravity e-comic, with the researches ages as described.

Define

The main activity carried out at the define stage is to examine the importance of developing android-based gravity e-comics in science learning. The analyses that have been carried out are: Performance analysis that examines the basic problems in learning science in grade 5 elementary schools, where elementary school students have difficulty learning science concepts, the lack of learning media that is interesting and in accordance with the cognitive level of grade V elementary school children, and the low learning independence of grade 5 elementary school students. Moreover, the characteristics of grade 5 students were analyzed through literature studies and surveys conducted in several elementary schools in Gorontalo City.

The results of the analysis show that the characteristics of elementary school students are that students can learn in a calm position for 30 minutes, so teachers must be creative in choosing appropriate learning methods and media that can motivate students to continue to be active in learning. Students only like to learning groups, so students have difficulty if given independent assignments by the teacher, to overcome this teacher must be creative in choosing media that can train students' learning independence. Where the results of research by Sari et al. (2021) show some things that were analyzed include needs, such as material, characteristics of students and learning media. The curriculum used in SMA Negeri 1 Garoga was the k-13 curriculum. Reaction rate material includes material that was difficult for students to understand, besides this material used a lot of calculations and also has practical activities.

The results of the analysis showed that a media that can lead students to be more active and able to visualize the subject matter was needed. Based on this, the learning media for chemical comics based on android were expected to help students understand the reaction rate more easily and interestingly. The results of this analysis indicate that the use of android-based Gravity e-comics can be used as a solution as a learning media for grade v elementary school students, where the results of research by Wibowo & Koeswanti (2021) show that the use of comics in the learning process can increase student learning independence. Still in the analysis stage, learning objectives are then analyzed to determine the competencies that students need to have after learning by using the android-based gravity e-comic learning media.

Design

The design of the android-based gravity e-comic begins with the preparation of the story narrative then proceeds with making comics. The following is given a view of the gravitye comic the main screen of the android.

Figure 1. E-comic app display on android main screen

To use the-comics application on the main android screen, students click on the app and the following image will appear on the student's android screen.

Figure 2. Android-based Gravity e-comic start screen

Clicks tart, and the following screen will appear on the android screen.

Figure 3. Android-based Gravity e-comichomescreen

Click start, then students can read the entire contents of the comic. Here are some content from the gravity e-comic story.

Figure 4. Content of gravity e-comic on android

The advantage of the application used is that internet data is only needed when students download this application, after that the application can be used without internet data, making it easier to use gravity e-comics in the learning process, because it is not hampered by the network and students who do not have internet can use this gravity e-comic as long as they have downloaded this application. Where the results of research by Panjaitan et al. (2021) show the clarity of pictures displayed was necessarily essential. The clear images with attractive colors can increasingly motivate students to study more.

In addition, this is in accordance with the views of Nazar *et.al*.(2020) that a learning media will provide fun elements so that it can foster interest and attractiveness of students to learn a concept that is complicated or boring. In addition, this is in accordance with the views of Lisnani & Gunadi (2020) that Educational games in the classroom tend to minimize distractions, thereby increasing the quality of teaching and learning beyond what is provided in conventional classrooms.

Development

At this stage, after the android-based gravity e-comic is finished in the form of a finished product, validation is carried out by science learning material experts and learning media experts. This validation process is carried out with the aim of getting suggestions and input from experts to improve the quality of android-based gravity e-comics. The following data is the results of expert validation of android-based gravity e-comics that have been designed at the previous stage.

Table 3. Science learning expert validation results

No.	Validator Assessment Aspect	Average Score	Assessment Category
1	Self Instruction	3.85	Very Valid
2	Self Contained	3.75	Very Valid
3	Stand Alone	3.50	Valid
4	Adaptive	3.75	Very valid
5	User Friendly	3.75	Very Valid

Based on the results of the validation of science learning experts, it can be seen that the gravitational science e-comic material is in a very valid and valid category. The self instruction aspect is in a very good category where the learning objectives contained in the gravity science e-comic are in accordance with the required competencies, the material exposure is in accordance with the required competencies, the material is presented coherently, easy to understand, the illustrations presented are in accordance with the material content, and the language used is easy for students to understand. Self contained aspect, the material in the science e-comic is in accordance with the required competencies and the competencies of the material presented contain the required competency units. In terms of stand alone, adaptive, and user friendly aspects, material in the science e-comic can be learned without the help of other media assistance, in accordance with the development of science and technology, can be learned any time and anywhere.

The results of the learning media expert validation are shown in Table 4

Table 4. Results of the learning media expert

No	Assessment Aspect	Average Score	Assessment Category
1	Attractive e-comic display	4	Very Valid
2	Appropriateness off on shape And size	3.5	Very Valid
3	Readability of text	4	Valid
4	Image quality	4	Very valid
5	Generates student interest	4	Very Valid

Based on Table 4, it can be seen that the android-based gravity e-comics are in the valid and very valid categories. This validator assessment was given after the researchers made revisions to the suggestions given by the experts, so that the resulting android-based gravity e-comic is valid and can be used in the learning process. This finding is in line with previous findings which state that comics are valid for use in the learning process (Lesmonoet et al., 2018; Zuhrowatiet et al., 2018; Sari et al., 2021; Adnyani & Wibawa, 2021).

After the android-based gravity e-comic was proven valid and could be used in the learning process, the research continued with a limited trial with 15 students in class VA SDN 80Kota Tengah. The results of the limited trial provided data on student responses and student learning independence as follows.

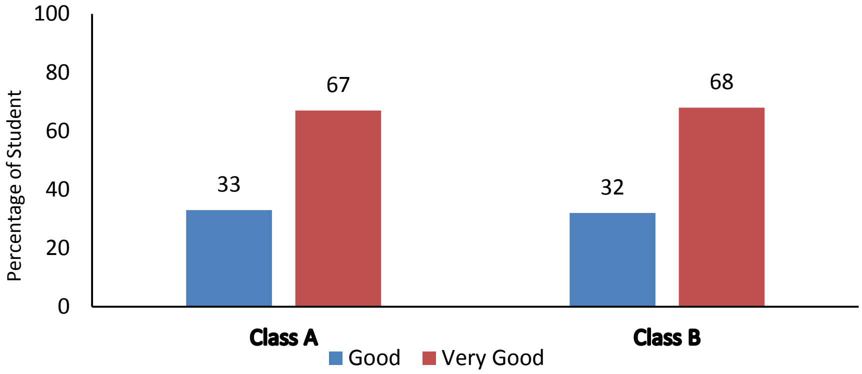

Figure 5. Percentage of student for each responses assesment

Figure 5 provides information that 33% of 15 people in class VA gave a good response to the use of android-based gravity e-comics, while 67% percent gave a very good response, while in class VB 32% of 25 students gave a good response and 68% gave a very good response. According to Rafikayuni, et al. (2017), response is a change in attitude caused by stimulation during the learning process. Furthermore, according to Amir & Arsyad (2015) the response consists of three main dimensions, namely the cognitive dimension, affective dimension and conative dimension. The cognitive component is indicated by the level of knowledge, views, or beliefs of students after using the media used (Darmawati & Thalib, 2017). It is further explained that the cognitive response is a response related to the view of an object, where the individual's mindset can be identified from the expression of beliefs, both which tend to be negative and positive. Affective response is an attitude object that is either positive expressed with pleasure or negative expressed with displeasure (Paranita, 2014). While the conative response is related to the tendency to act or behave towards an object (Hakim, 2016). In processing research data to determine student learning independence, it is calculated in the form of a percentage by dividing the total score obtained by the maximum total score then multiplied by 100% (Elistiani, et al., 2022).

Based on this, the researcher grouped student responses based on these dimensions, where the results were obtained as shown in Figure 6.

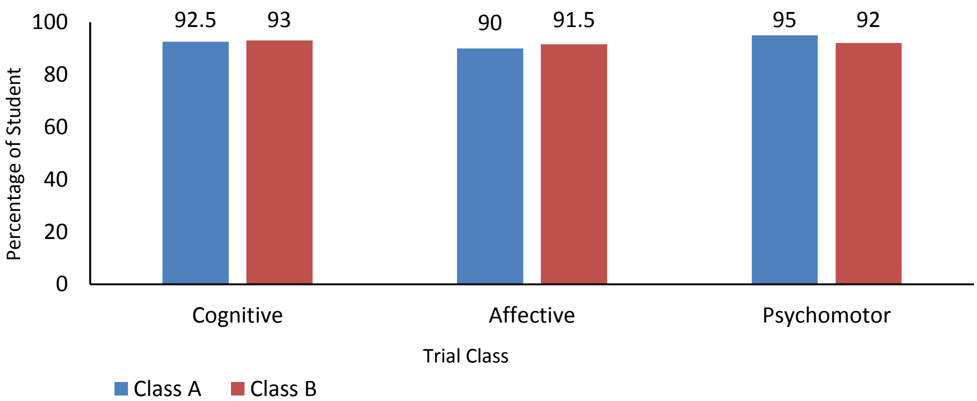

Figure 6. The response of class students in the cognitive dimension

Figure 6 shows that the response of VA class students in the cognitive dimension is 92.5%, the affective dimension is 90% and the conative dimension is 95%. These results indicate that for these three dimensions, student responses are in the very good category. For class VB students' response to the use of android-based gravity e-comics, it was found that the cognitive dimension was 93%, the affective dimension was 91.5% and the conative dimension was 92%. Similar results were presented by Topkaya & Yakup (2020) who suggested that students have a positive response to educational comics from both cognitive and affective aspects.

The findings for students' responses to this android-based gravity e-comic show that android-based e-comics are practical to use in the learning process. The same thing was revealed by Lova et al. (2013) who suggested that comics are very practical to use in the learning process, because in comics the material is presented in the form of clear and easy-to-read images. When viewed from the contents of comics with clear and attractive images and colors, comics can attract interest and motivate students to study hard (Sari *et.al*,2014; Panjaitan et al., 2021). Moreover, comics can also familiarize students to read, especially for students who lack interest in reading (Topkaya & Yilar, 2015).

Similar results were presented by Permata at al. (2022) Students with higher learning outcomes are found to have higher learning independence, students can identify their own learning needs, can use different learning methods and strategies, can manage their learning process independently, plan their time effectively, and evaluate learning outcomes to correct their deficiencies in learning. Furthermore, for the effectiveness of the android-based Gravity e-comic which is indicated by student learning independence, this study provides limited trial results in classes VA and VB in the form of classical student independence, as well as student independence in terms of learning independence indicators as described below.

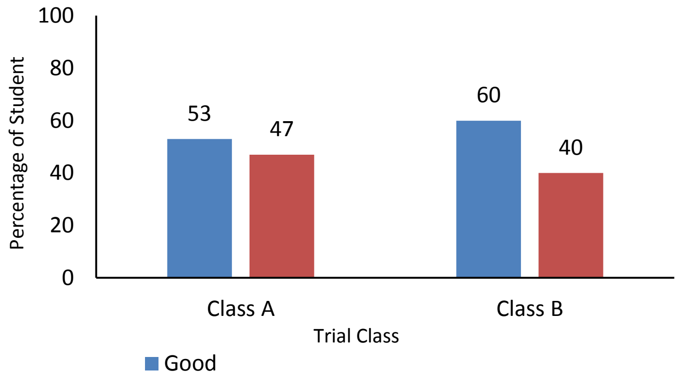

Figure 7. Students' learning independence after using the android-based gravity e-comic category.

Figure 7 provides information that in class VA 53% of 15 students have good learning independence, 47% others have excellent learning independence, while in class VB 60% of 25 students have good learning independence, while 40% others have excellent learning independence after using android-based gravity e-comics in the learning process. Furthermore, students' learning independence after using the android-based gravity e-comic, in terms of independence indicators, provides the following results.

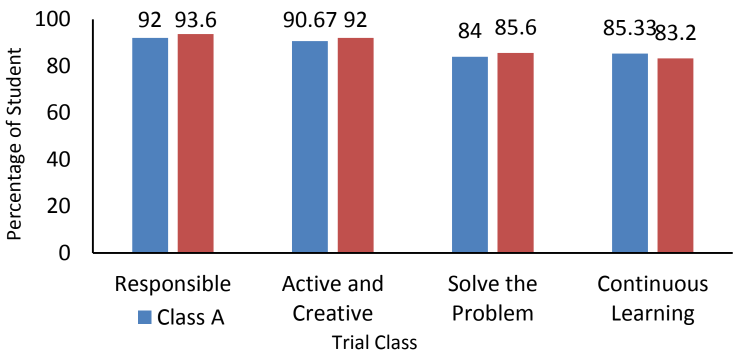

Figure 8. student independence for responsible indicators and active and creative indicators

Based on Figure 8, it can be seen that student independence for responsible indicators and active and creative indicators is in the very good category. For the indicator of solving problems in class VA is in the good category, while in class VB it is in the very good category. Another case for the indicator of continuous learning, both class VA and class VB student learning independence is in the good category. The results of this study indicate that the use of e-comics in science learning can train students' learning independence in elementary schools. This is in line with the results of research by Pramana & Dewi (2014); Linda et al. (2021) which shows that the use of android-based electronic learning media can increase student learning independence. These results are supported by the results of research by Ilhan et al. (2021) which states that the use of e-comics in learning can increase students' positive attitudes, where independence is one of the aspects of student attitudes that need attention.

The level of student independence in this study is shown by the attitude of being responsible, active and creative, solving problems and continuing to learn, the same thing was stated by Fahradina et al. (2014), where the level of student learning independence can be determined based on how responsible students are for playing an active role in the learning process, while according to Kizilcec et al. (2017), learning independence is characterized by students' ability to achieve learning goals through cognitive, affective, motivational, behavioral and metacognition processes.

Diseminate

At this stage, product packaging is carried out, where the android-based gravity e-comic application and instructions for use are disseminated to users, in this case science teachers in elementary schools, so that they are easily understood and can be used in the learning process more widely. These results are supported by the results of research by Rahmayani (2019) The learning process should not only improve students' cognitive learning outcomes, but also pay attention to affective aspects. In this case, the character of students, including the character of independence, where independence is important in a learning process because being independent in the learning process will affect student achievement.

Conclusion

This research results in an android-based Gravity e-comic that is valid, practical to use in the learning process, where students respond positively to its application, and effective in increasing student learning independence at the elementary school level. This android-based gravity e-comic is recommended to be used in the learning process at school to increase student learning independence.

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References

Akcanca, N. 2020. An alternative teaching tool in science education: educational comics. *International Online Journal Education and Teaching,* 7(4):1550–1570. *https://iojet.org/index.php/IOJET*

Akker, J.V.D. 1999. Principles and Method of Development Research. London:Academic Publisher.

Adnyani, K.A.D. & Wibawa, I.M.C. 2021. Alternative energy sources on digital comicmedia. *Internatiounal Journal of Elementary Education,* 5(1):61-70. 10.23887/ijee.v5i1.34333

Amir, M., Muris, & Arsyad, M. 2015. Pengembangan perangkat pembelajaran berbasis pengalaman pada peserta didik kelas XI IPA SMA Negeri 9 Pinrang. *Jurnal Sains dan Pendidikan Fisik*a. 11 (3):202- 213. https://doi.org/10.35580/jspf.v11i3.1756

Ariah. 2015. Pembentukan karakter kemandirian siswa melalui implementasi islamic full day school. *Didaktika Tauhidi*, 2(2):121-128.https://doi.org/10.30997/dt.v2i2.309

Arikunto, S. 2013. Prosedur Penelitian Suatu Pendekatan Praktik. Edisi Revisi. Jakarta: PT. Rineka Cipta

Astuti, I.A.D., Dewati, M., Okyranida, I.Y., & Sumarni, R.A. 2019. Pengembangan media smart powerpoint berbasis animasi dalam pembelajaran fisika. N*avigation Physics: Journal of Physics Education*, 1(1):12-17. https://doi.org/10.30998/npjpe.v1i1.191

Avrillianti, H., Budiawanti, S., & Jamzuri. 2013. Penerapan media komik untuk pembelajaran fisika model kooperatif dengan metode diskusi pada siswa SMPN 5 Surakarta kelas VII tahun ajaran 2011/2012 materi gerak. *Jurnal Pendidikan Fisika,* 1(1):156-163. https://jurnal.fkip.uns.ac.id/index.php/pfisika/article/view/1790/1283

Awiegerova, A. & Navratilova, H. 2017. Let's not be scared of comics (researching possibilities of using conceptual comics in teaching nature study in Kindergarden). Procedia *Social and Behavioral Sciences*, 237:1576-1581. https://core.ac.uk/reader/97494750

Azizah, N. & Siti, K. 2014. Pengaruh komik sains dalam pembelajaran IPA terhadap pengembangan karakter siswa di Kecamatan Semarang Tengah. *Unnes Physics Education Journal*, 3(3):34-42. https://doi.org/10.15294/upej.v3i3.4329

Buchori, A. & Setyawati, R. D. 2015. Development learning model of charactereducation through e-comic in Elementary School. *International Journal of Education and Research*, 3(9):369-386. https://www.ijern.com/journal/2015/September-2015/30.pdf

Casumpang, P. F.H. & Enteria, O.C. 2019. Effectiveness of developed comic strips asinstruc-tional material in teaching specific science concepts. *International Journal for Innovation Education and Research,* 7(10):876–882. https://doi.org/10.31686/ijier.vol7.iss10.1835

Damopolii, I., Theresia, L., & Genc, O.I. 2021. Digital comics in online learning duringcovid-19: its effect on student cognitive learning outcomes. *International Jounral of Interactive Mobile Technologies (iJIM),* 15(19):33-47. https://doi.org/10.3991/ijim.v15i19.23395

Darmawati, D. & Thalib, A. 2017. Respon siswa Madrasah Aliah Negeri (MAN) terhadap radikalisme agama di Makassar. *Sulesana: Jurnal Wawasan Keislaman*, 10(1):19-48. https://doi.org/10.24252/.v10i1.1798

Elistiani, E.E., Ira, L.R.R., & Rody, P.S. 2022. Analisis kemandirian belajar siswa Madrasah Tsanawiyah Negeri di Kota Pontianak pada mata pelajaran IPA. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 6(2):195-206. https://doi.org/10.24815/jipi.v6i2.25494

Fahradina, N., Ansari, B.I., & Saiman. 2014. Peningkatan kemampuan komunikasi matematis dan kemandirian belajar siswa SMP dengan menggunakan model investigasi kelompok. *Jurnal Didaktik Matematika*, 1(2):64-72. http://dx.doi.org/10.22373/jppm.v3i2.7352

Hakim, A.B. 2016. Efektivitas penggunaan e-learning moodle, goole classroom dan admomo. *I-Statement STIMIK ESQ*, 2(1):1-4. https://www.scribd.com/document/426648168/hai

Huda, M. 2013. Model-Model Pengajaran dan Pembelajaran. Yogyakarta: Pustaka Pelajar.

Ilhan, G.O. & Oruc, S. 2019. Comic books use in social studies lesson: Texas history. *Egit. ve Bilim*, 44(198):327–341,Retrievedfromhttps://doi.org/10.15390/EB.2019.7830

lhan, G.O., Kaba, G., & Sin, M. 2021. Usage of digital comics in distance learning duringcovid-19. *International Journal on Social and Education Sciences*. Retrieved from. https://doi.org/10.46328/ijonses.106

Kizilcec, R.F., Sanagustin, M.P., & Maldonado, J.J. 2017. Self-regulated learning strategies predict learner behavior and goal attainment in massive open online courses. *Journal of Computers and Education*, 104: 18-33. https://doi.org/10.1016/j.compedu.2016.10.001

Koutnikova, M. 2015. The Application of Comics in Science Education. *Acta EducationisGeneralis,* 7(3):88-98.https://doi.org/10.1515/atd-2017-0026

Lesmono, A.D., Bachtiar, R.W., Maryani, & Muzdalifah, A. 2018. The instructional-based andro-web comics on work and energy topic for Senior High School students. *Jurnal*

Pendidikan IPA Indonesia, 7(2):147-153. Retrieved from. https://doi.org/10.15294/jpii.v7i2.14245

Linda, Zulfarina, Mas'ud, & Putra, P.P. 2021. Peningkatan kemandirian dan hasil belajar peserta didik melalui implementasi e-modul interaktif IPA terpadu tipe connected. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(2):191-200.https://doi.org/10.24815/jpsi.v9i2.19012

Lisnani & Gunadi, E. 2020. Analisis penggunaan aplikasi kahoot dalam pembelajaran IPA. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, 4(2): 155-167. https://doi.org/10.24815/jipi.v4i2.16018

Nana, S.S. 2016. Metode Penelitian Pendidikan. Bandung: Remaja Rosdakarya.

Nazar, M., Zulfadli, Anggi, O., & Puspita, K. 2020. Pengembangan aplikasi pembelajaran interaktif berbasis android untuk membantu mahasiswa dalam mempelajari materi larutan elektrolit dan nonelektrolit. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 8(1):39-54. https://doi.org/10.24815/jpsi.v8i1.16047

Nieveen, N. 1999. Prototype to reach product quality, dalam. van den Akker, J., Branch, R.M., Gustafson, K., Nieveen, N., & Plomp, T. (pnyt.). Design approaches and toolsin educational and training. Dordrecht: Kluwer Academic Publisher.

Nurgiyantoro, B. 2013. Teori Pengkajian Fiksi. Yogyakarta : Gadjah Mada UniversityPress.

Nurohimah, S., Kurniawan, E.S., & Ashari, 2012. Pemanfaatan kartun fisika sebagai media pembelajaran untuk meningkatkan motivasi belajar pada siswa kelas VII MTsN Purworejo. *Jurnal radiasi,* 1(1):45-48 https://jurnal.umpwr.ac.id/index.php/radiasi/article/view/336/214

Panjaitan, R.G.P., Shidiq, G.A., Pratiwi, W.M., & Yokhebed. 2021. Developing picture storybook in the human excretory system concepts for improving students' interests science learning*. Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 9(3):391-406. https://doi.org/10.24815/jpsi.v9i3.20396

Papadakis, S. 2020. Robots and robotics kits for early childhood and first schoolage. *International Journal of Interactive Mobile Technologies,* 14(18):34-56. https://doi.org/10.3991/ijim.v14i18.16631

Paranita, L. 2014. Sikap masyarakat Surabaya terhadap tayangan talkshow@show_Imah di Trans TV. *Jurnal E-Komunikasi*, 2(1):1-10. https://publication.petra.ac.id/index.php/ilmu-komunikasi/article/view/1736

Permata, V.W., Sahputra, R., Erlina, Sartika, R.P., & Rasmawan, R. 2022. Hubungan antara kemandirian belajar dengan hasil belajar kimia kelas X MIPA di SMA Negeri 6 Pontianak. *JIPI (Jurnal IPA dan Pembelajaran IPA),* 6(4):423-437. https://doi.org/10.24815/jipi.v6i4.27418

Pramana, W.D., & Dewi, N.R. 2014. Pengembangan e-book IPA terpadu tema suhu dan pengukuran untuk menumbuhkan kemandirian belajar siswa. *Unnes Science Education Journal*, 3(3):602-608. Retrieved from. https://doi.org/10.15294/USEJ.V3I3.4267

Putri, D.Y.K.P. & Ariyanti, G. 2015. Pengembangan komik matematika sebagai media pembelajaran berbasis pendidikan karakter pada materi perkalian bilangan bulat Sekolah Dasar. *Jurnal Ilmiah Edukasi Matematika (JIEM)*, 23(1):22-38. http://portal.widyamandala.ac.id/jurnal/index.php/jiem/article/view/244/278

Rafikayuni, R., Eka, A., & Reni, M. 2017. Pengembangan LKS berbasis predict observe explanation pada submateri keanekaragaman hayati kelas X. *Jurnal Pendidikan dan Pembelajaran Khatulistiwa,* 6(11):1-12. http://dx.doi.org/10.26418/jppk.v6i11.22734

Rahmayani, F. 2019. Hubungan Antara Karakter Mandiri Belajar Dengan Hasil Belajar Siswa. *Jurnal Pendidikan Edutama*, 6(2):87-93. http://dx.doi.org/10.30734/jpe.v6i2.510

Riwanto, M. A. & Budiarti, W.N. 2020. Development of digital science comics for elementary school as a support for digital literacy in online learning, *in Proceedings of the 4th Inter-national Conference on Learning Innovation and Quality Education*, 15(19):1-4. Retrieved from. https://doi.org/10.1145/3452144.3452221iJIM

Sari, A.M. & Lubis, T.E. 2021. Development of chemistry comics based on android and its implementation to improve learning outcomes. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 9(3):433-444. https://doi.org/10.24815/jpsi.v9i3.20266

Topkaya, Y. & Bayram, Y. 2015. Analysis student views related to educative comics. *Route Educational and Social Science Journal*, 2(3):106-117. http://www.ressjournal.com › Makaleler

Topkaya, Y. & Dogan, Y. 2020. The effect of educational comics on teaching environmental issues and environmental organizations topics in 7th grade social studiescourse:amixedresearch. *Educationand Science*, 45(201):167-176. https://www.academia.edu/41848430/The_Effect_of_Educational_Comics_on_Teaching_Environmental_Issues_and_Environmental_Organizations_Topics_in_7th_Grade_Social_Studies_Course_A_Mixed_Research

Wang, L. 2022. Cartoon-Style Image Rendering Transfer Based on Neural Networks. *Computational Intelligence and Neuroscience*, 1-10. https://doi.org/10.1155/2022/2958338

Wibowo, S.A. & Koeswanti, H.D. 2021. Pengembangan Media pembelajaran berbasis komik untuk meningkatkan karakter kemandirian belajar siswa Sekolah Dasar. *Jurnal Basicedu,*5(6):5100-5111. https://doi.org/10.31004/basicedu.v5i6.1600.

Wahyu, J.W., Japar, M., & Erry, U. 2021. Development of digital based comic media for primary v-class student learning. *International Journal of Multicultural and Multireligious Understanding*, 8(4):532-537. Retrieved from. https://doi.org/10.18415/ijmmu.v8i4.2601

Widoyoko, E.P. 2012. Teknik Penyusunan Instrumen Penelitian. Yogyakarta: Pustaka Pelajar.

Wuryandani, W., Fathurrohman, F., & Ambarwati, U. 2016. Implementasi pendidikan karakter kemandirian di Muhammadiyah Boarding School. *Jurnal Cakrawala Pendidikan*, 15(2):208–216. Retrieved from. https://doi.org/10.21831/cp.v15i2.9882

Yulianti, D., Khanafiyah, S., & Sulistyorini. 2016. Inquiry-based science comic physics series integrated with character education. *Jurnal Pendidikan IPA Indonesia,* 5(1):38-44. Retrieved from. http://dx.doi.org/10.15294/jpii.v5i1.5787

Yulinda A. & Ansari, K. 2019. The feasibility of comic media on narrative texts based on local wisdom in VII Grade Student of Junior High School (SMPN) 3 Kotapinang. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal,* 2(3):147-163. Retrieved from. https://doi.org/10.33258/birle.v2i3.369

Zainal, A. 2013. Model, Media, dan Strategi Pembelajaran Kontekstual. Bandung: Yrama Widya.

Zuhrowati, M., Abdurrahman, & Suyatna, A. 2018. Pengembangan komik sebagai mediapembelajaran ipa pada materi pemanasan global. *Jurnal Pendidikan Fisika,* 6(2):144-158. http://dx.doi.org/10.24127/jpf.v6i2.1305

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Development of Android-based Augmented Reality Learning Media on Atomic Matter

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Abstract. Material and limited chemistry learning media resulted in less than optimal student scores. Necessary to develop learning media that can support studying by utilizing technology. This study aims to determine the quality and develop android based augmented reality learning media on atomic material. The type of research used is development research with the 4-D model (define, design, develop, and disseminate, which is limited to the development stage. The product was validated by one media expert lecturer, one material expert lecturer, and three reviewers (senior high school teachers) and responded to by ten senior high school students. The instrument used was a product quality sheet with a Likert scale and a student response sheet with a Guttman scale. The product's characteristics developed in the form of an application with atomic materials, augmented reality cameras, and student quizzes. The results of the quality assessment by media experts got a percentage of 97.14%, by material experts got a percentage of 83.33%, and the reviewer got a percentage of 95.8% with a very good category. The product was responded to positively by students with a percentage of 99%. Based on these results, android-based augmented reality learning media on atomic material in senior high school can be used as an alternative learning media to increase student interest in learning chemistry.
Keywords: Development research, augmented reality, atom

Introduction

The 2013 curriculum requires teachers to carry out the learning process of building students' knowledge, skills, and attitudes (Ramadani et al., 2020). Implementation of the 2013 curriculum, some teachers still use old model devices, and the learning process in the classroom still applies to learning using the lecture method so that learning becomes passive (Kholisho & Marfuatun, 2018). for students to be active during learning, teachers are expected to use suitable examples, approaches, and methods to attract student interest and build students' abilities in each subject, especially science, namely chemistry (Ramadani et al., 2020).

Chemistry is a subject that is considered difficult for students because it has never been studied before and requires a reasonably high understanding (Rikawati & Sitinjak, 2020). Relatively new chemistry material because failing to receive chemical sains subjects in junior high school is the cause of alchemy challenging to learn. The characteristics of chemistry in junior high school are abstract materials whereas, in junior high school, chemistry includes acids, bases, and salts; elements and ways of writing emblems; chemical formula of the compound; mixtures and some properties of solutions; chemical changes; particles of matter; and household chemicals (Manasikanal et al., 2022). In addition, concepts in chemistry that are generally abstract have the potential to cause difficulties in students and reduce student motivation to learn chemical sains. One abstract material that makes it difficult for students to learn chemistry is atomic structure substance, so the students must understand these concepts correctly and sincerely. So that students have difficulty in solving problems on the subject of atom structure, namely on concept problems, because students only memorize and need help understanding the concept correctly (Afrianis, 2022). students need help imagining atomic models based on atom inventors (Oktiarmi, 2020).

Chemistry study emphasizes direct study experiences through used process skills development and scientific behavior, which can be done with practicum, teaching aids, tutor materials, and learning media (Ruslan & Putri, 2018). Learning media can make it easier for students to understand the material and like studying (Mawarni, 2018). Therefore, it is necessary to utilize technology to develop learning media to increase student motivation in study (Mufida et al., 2022). Based on an interview with a chemistry teacher at 1 Jetis Senior High School in November 2021 stated that the limited chemical sains learning media in the form of printed books or LKS on the material makes students feel that they do not understand the atomic matter properly, so it is necessary to develop learning media that can support study, one of which is utilizing technology. Technology can be used as an exciting learning medium for students without reducing the essence of the material (Nandyansah, 2019). One example of learning media that can be concreted by utilizing technological developments in the field of Education is android-based learning media (Kuswanto & Radiansah, 2018). Augmented reality (AR) android-based technology currently being developed (Harahap et al., 2020). AR a technology that is still new and still has little use for people in Indonesia. Hence, the use of AR is one of the alternative learning media to make the learning process more fun and exciting. AR can also be used to overcome printed books, modules, or trainers that are pretty expensive and can be purchased by schools. Augmented Reality is an attempt to combine the natural and virtual worlds created through a computer to make the boundary between the two thin by utilizing 3D animation technology visualized through Augmented Reality using devices. AR is a technology that can transform two-dimensional or three-dimensional virtual objects into a natural environment and project them in real-time (Nirwanto, 2021).

The use of educational media AR can directly provide learning wherever and whenever students want to carry out the learning process (Yuliono et al., 2018). Based on the results of interviews with chemistry teachers in schools, it is necessary to develop a learning media to realize abstract chemistry learning materials, especially on the atomic matter, where using AR can visualize explanations of atoms so that chemistry learning is more interactive, practical, and varied. In addition, using AR learning media can increase student interest in learning chemistry. In addition, according to Nirwanto (2021), AR in education has a positive impact, namely being attractive for multimodal learning, increasing the accessibility of educational content, increasing student control over educational content collaborative learning opportunities, motivating students to be actively involved, and turning something abstract into the concrete. There are even significant differences in learning outcomes using AR learning media that can increase student understanding (Uliontang et al., 2020). Research related to android-based AR learning media development on the atomic matter has yet to develop. Therefore, researchers focus on developing android-based AR learning media on atom matter to know the characteristics of learning media, the quality of learning media, and student responses to android-based AR learning media on atomic matter in high school. This learning media can be an alternative learning medium for atom matter and increase students' interest in learning chemistry (Arum, 2022). This study aims to determine the characteristics and quality of android-based AR learning media on atomic material based on assessments from material experts, media specialist and teachers, and to determine student responses to the product.

Methods

This research uses a development model, name research and development (R&D). This development research method aims to produce a product and test students' responses to the product developed (Rahmawati, 2022). The procedure used is the 4-D development model, according to Thiagarajan (1974) the 4-D model is divide into 4 stages, namely define, design, development, and disseminate (Azmi, 2022). This research is limited to the development stage. The products developed in this study are augmented reality android applications and marker cards on the atomic matter. The procedure in this study can be seen in Figure 1. Products were review by peer reviewers, namely three chemistry education students of UIN Sunan Kalijaga Yogyakarta to provide suggestions, validated by one material expert and one media expert, and assessed for quality by three reviewers, namely one chemistry teacher in each school (MBS Pleret Yogyakarta, MA Muhammadiyah 1 Yogyakarta, and SMA Negeri 1 Jetis Bantul), and respond by five students of class X MIPA SMA Negeri 1 Jetis and five students of class X MIPA MBS Pleret Yogyakarta.

The data collection techniques used are indirect communication using 5-scale product quality assessment questionnaire sheet instruments for material experts, media experts, and teachers and Guttman scale questionnaires for student responses. The grid of augmented reality media quality assessment instruments can be seen in Table 1.

Table 1. Augmented reality media quality assessment grid

Aspects	Number of indicators	Material Expert	Media Expert	Teacher
Presentation of the material	3	√		√
Material	5	√		√
Language	2	√	√	√
Uselfulness	2	√		√
Visual communication	2		√	
Software engineering	3		√	√

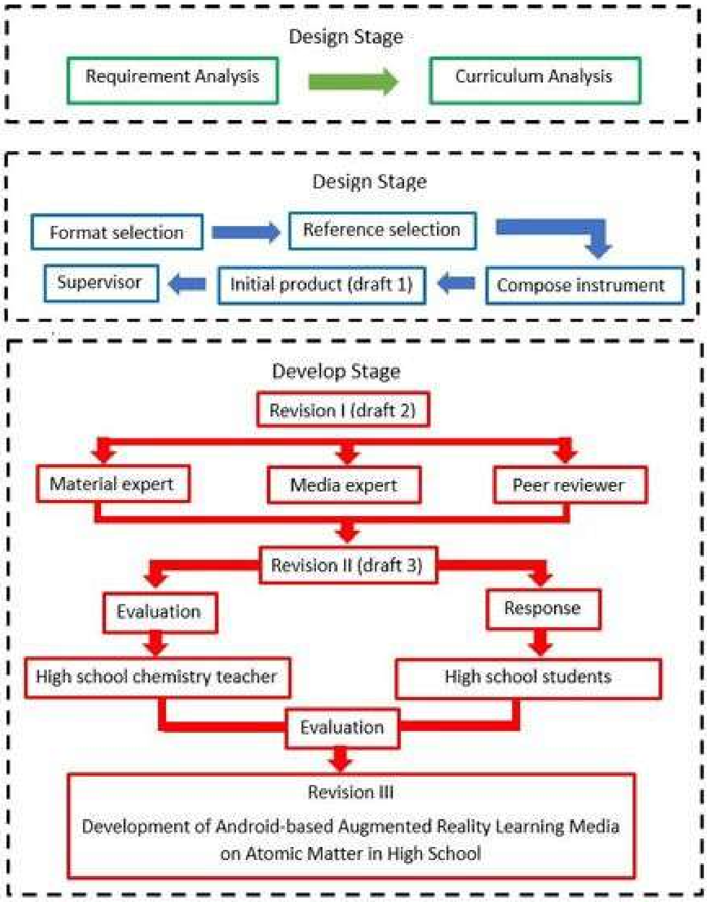

Figure 1. Research procedure for learning media development

Data in the form of input from material, media experts, peer reviewers, and teachers are analyzed descriptively to revise the product. Data analysis of product quality assessment results from material, media experts, and teachers was carried out to obtain numerical scores with scores in the form of letters (qualitative) converted into scores (quantitative) with provisions based on scales (Azmi, 2022) in Table 2. Then the average of all aspects and each aspect of the assessment is calculated using formula (1). Furthermore, the scores obtained are converted into qualitative data based on the ideal assessment criteria in Table 3. Next, the percentage of product ideality is calculated as a whole and each aspect using formula (2).

$$\bar{x} = \frac{\sum x}{n} \qquad (1)$$

with

$\bar{x}$ = Average of score

$\sum x$ = The total score of each rater

n = Number of appraisers

Table 2. Convert qualitative data into quantitative data

Category	Score
Very good	5
Good	4
Enough	3
Less	2
Very lacking	1

(source: Rohmah, 2020).

Table 3. Ideal assessment criteria

Scor range	Category
$\bar{x} > (Mi + 1,8\ Sbi)$	Very good
$(Mi + 0,6\ Sbi) < \bar{x} \leq (Mi + 1,8\ Sbi)$	Good
$(Mi - 0,6\ Sbi) < \bar{x} \leq (Mi + 0,6\ Sbi)$	Enough
$(Mi - 1,8\ Sbi) < \bar{x} \leq (Mi - 0,6\ Sbi)$	Less
$x \leq (Mi - 1,8\ Sbi)$	Very lacking

(source: Rohmah, 2020).

Analysis of learner response data from qualitative data is converted into quantitative data based on the Guttman scale. The average value for the entire aspect is calculated using formula (1). Then calculated the percentage of overall product ideality and each aspect formulated by the research result score divided by the maximum idea score multiplied by 100%. The Guttman scale is used for data analysis techniques for student response results to obtain quantitative data (scores) which were originally qualitative (Rahmawati, 2022), the score on the Guttman scale will be 1 if the answer is "Yes" and 0 if the answer is "No".

Result dan Discussion

Android-based AR learning media on atomic matter developed in this study is a type of R & D using a 4-D model. The 4-D stage consists of four stages, namely define, design, develop, and disseminate. This research is only limited to the development stage. The description of the study is as follows.

Define

The define stage is carried out with initial analysis, needs, and curriculum. Literature studies from various sources such as journals regarding product needs must be developed and observations of students about the learning media used are things done for initial analysis. The initial analysis stage is carried out to determine the needs and problems experienced and faced by students in chemistry learning. The initial analysis was carried out by studying literature from various sources such as journals regarding the need for products to be used as learning media and supplies of learning media used in the classroom. In addition, observations were also made to students regarding the use of learning media in class.

The results of the initial analysis are then deepened again by knowing the learning process in a class by analyzing needs. Then interviews were conducted with chemistry teachers at SMA Negeri 1 Jetis and MAN 2 Kulonprogo to find out the needs, problems, and obstacles during learning as a needs analysis. The interview results stated that educators still use conventional learning media such as books and student worksheet so students feel bored with the media used. This resulted in students' interest in learning chemistry.

It is necessary to develop learning media innovations that utilize technology such as AR so that students do not feel bored when learning atomic matter chemistry. In addition, learning media has advanced and developed along with the birth of the communication revolution which is used for learning purposes other than pre-existing media such as teachers, textbooks, and whiteboards (Yaumi, 2018). The use of interesting learning media can also increase the imagination of students in learning. Furthermore, curriculum analysis is carried out by analyzing Core competencies and basic competencies (KD) in the 2013 curriculum for the 2021/2022 academic year. The curriculum analysis aims to establish competencies to be developed on android-based augmented reality on the atomic matter. The result of the curriculum analysis is the KD are selected to be the target of development.

Design

The design stage is carried out by selecting media and formats, references, preparing instruments, and the initial design of the product to be made. Based on the initial analysis, needs analysis, and curriculum analysis the media developed is an android-based AR. The selection of learning media formats is adjusted to the chemistry and characteristics of students obtained from observations and interviews. The material in this learning media is atomic. The selection of formats developed includes learning objectives, materials, AR cameras, instructions, and quizzes.

The medium to be created in AR is an atomic matter which includes: the development of atomic models, atomic structure, and atomic number and mass number. The development material of the atomic model is equipped with AR3D modeling of the atom so that the atomic model can be visualized. Reference material to be used is obtained from college chemistry books, high school chemistry textbooks and LKS, research journals, and youtube. After all the material is collected, the learning media is made by unity, vuforia SDK, blender, and corel draw. The selection of 3D Blender is reviewed from the aspects of modeling and animation (Mongilala et al., 2019). While the Vuforia SDK is used to analyze images by detecting markers so the information is generated in the form of 3D objects created (Firdanu et al., 2020).

Instrument making is done by studying literature on the criteria of android-based AR as a good learning medium and adopting several instruments that have been made before then instruments that have been compiled in validation by instrument experts. The material that has been prepared, the design of the application design, and the functionality of the application are used as considerations for making instruments. Instrument-making is done by looking at aspects and indicators regarding the product to be developed.

The initial design stage (draft I) was made by designing media content and preparing android-based AR applications. Microsoft word is a reliable word processing program and is most widely used by computer users, so the design of media content uses word office applications (Septian, 2019). In materials designed to be arranged into developed media, it is not 100% KD of atomic matter. This is because if all material according to KD is arranged into development media, it will affect the size of the application which becomes large, so it takes up a lot of storage memory in the user's android. Furthermore, the preparation of android-based augmented reality by 1) designing a design, using corel draw where the advantage of this vector is that the image will have a relatively small file capacity (Afriansyah, 2018), then choosing background colors and icons, 2) making 3D modeling of atomic shapes using the blender application which is a series of free and open source 3D creations, which supports the overall 3D concept, namely modeling, rigging, animation, simulation, rendering, compositing, and motion tracking, even video editing and game making (Mongilala et al., 2019). The 3D shapes made are ten objects including the Dalton atomic model, Thomson atomic model, two Rutherford atomic models, two Bohr atomic models, quantum mechanical atomic models, cathode ray firing experiments, and alpha ray shooting experiments, 3) creation of a license in the Vuforia SDK, the finished barcode is then licensed to the Vuforia SDK to find out the level of sensitivity if the barcode is scanned by the application. Vuforia uses consistent sources of computer vision that focus on image recognition, but it has many features and capabilities that can help developers to realize their thoughts without technical boundaries. Vuforia supports developers to create applications that can be used on almost all types of smartphones and tablets (Mongilala et al., 2019), 4) combining assets into Unity which is used to develop multi-platform games and can also be used to create three-dimensional animations. The designs that have been made are then put into unity and then bolted programs and coding to make the application run as the developer wants. Unity is great and full of professional applications. The editor in Unity is made with a simple user interface (Mongilala et al., 2019), 5) the resulting product (draft I) is an Android-based augmented reality learning media on the atomic matter. The product developed has several components, namely the homepage, main menu in which there is a menu of hint buttons, competencies, materials, AR cameras, quizzes, developers, and exits. The homepage is the initial screen before starting the application, inside the homepage there is a start button to start the application, and when opening the application will appear music as an accompaniment when the application runs.

The characteristic of android-based augmented reality developed is the integration of atomic matter with technological aspects to visualize atomic models. So that it can be an alternative learning medium in the classroom. The use of augmented reality in chemistry learning is in line with the times by studying the atomic matter, visualizing atomic models through AR cameras, and ending with an atomic matter quiz.

Develop

After the product (draft I) is revised based on advice and input from experts, a revised product (II) is produced. Furthermore, draft II was corrected by three peer reviewers and validated by one lecturer, material expert, and media expert. Suggestions and input from material experts, media experts, and peer reviewers are used for revision II materials and refining the product. Furthermore, the revision II product (draft III) was assessed by three reviewers (high school / MA chemistry teachers) and responded to by ten high school students from grade XI MIPA to obtain data and input for revision III material as the final product. The final media product developed is an android-based augmented reality application on atomic matter equipped with marker cards, applications, and marker cards can be downloaded at https://drive.google.com/drive/folders/1QrYH_SEwj0CWmaMz0e_MUPuUP7uB_TV5 addresses via android devices. As for using the application, it does not require an internet network so it can be used anytime and anywhere. The final product specifications include 1) Homepage (Figure 2); 2) Main menu (Figure 3); 3) Instructions (Figure 4); 4) Competence (Figure 5), 5) Material (Figure 6); 6) AR camera (Figure 7); 7) Quiz (Figure 8); 8) Developer (Figure 9); 9) Exit button and AR card (Figure 10).

Figure 2. Homepage

Figure 3. Main menu

Figure 4. Instructions

Figure 5. Competence

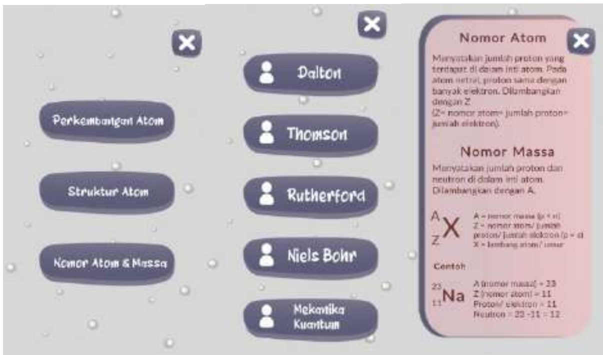

Figure 6. Material

Figure 7. AR camera

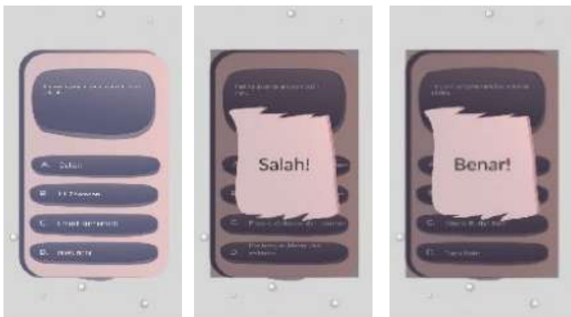

Figure 8. Quiz

Figure 9. Developer

Figure 10. AR card

Product Assessment Result

The results of validation by material experts as a whole received a score of 50 with an ideal percentage of 83.33% and were included in the good category. Further-more, the results of validation by media experts as a whole received a score of 34 with an ideal percentage of 97.14% and were included in the very good category. The assessment results of three reviewers (high school chemistry teachers) overall received an average score of 67.3 with an ideal percentage of 95.8% and included in the very good category. The response results of ten students as a whole received an average score of 99 with a percentage of the ideality of 99%. Data on the results of validation, assessment, and student responses can be seen in Table 5.

Based on the results of the research data the products developed are very good. The learning media developed can increase student interest in learning where the application can be used as an alternative to independent learning, add references to learning resources, and foster enthusiasm for learning. The use of interesting learning media can generate new desires and interests for students, In addition, the creativity of ideas is very good by providing an attractive, original look, and following the needs of the times. An attractive media display will make it easier for students to understand the material so that students do not feel bored learning (Wibowo & Koeswanti, 2021).

Table 5. Data from the validation of material experts, media experts, reveiwer assessment, and student responses

Response	Assessment aspect	$\sum$ Indicator	$\sum$ Score	Total	Ideality	Category
Material expert	Presentation of material	3	14	50	83.33%	Good
	Material	5	20			
	Language	2	8			
	Uselfulness	2	8			
Media expert	Language	2	10	34	97,14%	Very good
	Visual communication	2	10			
	Software engineering	3	14			
Reviewer (Chemistry teacher)	Presentation of materia	3	15	67.3	95.8%	Very good
	Material	5	24			
	Language	2	9.3			

	Uselfulness	2	9.7			
	Software engineering	2	9.3			
Senior High School students grade X MIPA	Visual communication	1	10	99	99%	Very good
	Presentation of the material	2	19			
	Material	3	30			
	Software engineering	1	10			
	Language	2	20			
	Uselfulness	1	10			

Based on the research data results, aspects of the material presented in the products developed are very good and follow the core competencies and KD in the applicable curriculum. According to Rahmawati (2022), the suitability of KD will affect student development and material presentation. The systematic and straightforward presentation of material on this media is very good; the material is arranged systematically, there is no overlap in the delivery of material, and the material delivered is per the indicators. If the material presented is correct, it can prevent misconceptions and understanding for students (Azmi, 2022). Media that can be used anytime and anywhere is very good flexible media used anytime, anywhere can be applied offline and is up to date following the latest developments in science and technology. Using learning media through the development of science and technology can improve student learning outcomes (Lestari et al., 2020). This is also following research conducted by Arum (2022), obtaining an average result of 98.3% in the very good category so that the AR produced is suitable for use as a learning medium.

The results of the research data show that the material aspect of the developed product is very good with the criteria of images presented clearly and attractively, 3D images introduce students to atoms, emphasize direct experience to students, writing chemical terms is correct, and 3D images of atoms have presented their original form. The resulting product follows research by Rahmawati (2022) that the image is presented clearly and attractively, namely a precise 3D image, appropriate image size, and picking image design. So that the quality of images in the media can help understand the material and support the material. In addition, 3D drawings introduce students to atoms so that they can visualize their shape, explain their development, and facilitate the understanding of atomic matter. According to Azmi (2022), displaying interesting 3D objects can increase learners' attention. The products developed also emphasize direct experience to students so that students can operate applications, scan barcodes, view 3D images directly, and study atomic matter independently. The research by Azmi (2022) shows that students will be able to find their knowledge and develop critical thinking skills. In addition to direct experiences that students can feel, students also experience new experiences using augmented reality technology learning media (Mongilala et al., 2019). Writing chemical terms on products uses chemical terms and symbols that have been learned and uses terms that are easy to understand so that they do not cause double meaning, so do not cause debate, do not have many interpretations, and do not cause misconceptions and doubts (Rahmawati, 2022). Using 3D images on products helps students better understand atoms and can prevent misconceptions about the material (Hilda et al., 2021).

The linguistic aspects of the products developed in this study are very good with PUEBI and communicative suitability criteria. In the developed product, the language used follows PUEBI, including writing letters, sentences, punctuation, and hyphenation of syllables. This shows that the language follows rules (Ramadani et al., 2020). In addition, the language used in communicative products is easy to understand, so it can clarify the sentence to be conveyed. According to Azmi (2022), using easy-to-understand language will clarify the sentence's meaning, and compliance with Indonesian rules will make it easier for students to understand the material.

The results of the research data show that the usefulness aspect of the product developed is very good with the criteria for using the product to make it easier for teachers to deliver material, and the use of products can increase student learning interest. The use of products greatly facilitates teachers in delivering material. This follows research by Asnawati (2019); efforts and use of learning media in schools still need improvement. The learning material teachers deliver only explained conventionally so that the products developed are beneficial and facilitate teachers' learning process. The products developed can also increase student interest in learning, where the product can be used as an alternative to independent learning, add references to learning resources, and foster enthusiasm for learning. Using attractive products can generate new desires and interests in students, generate learning motivation, and even psychologically influence students (Rif & Nur, 2021).

The results of research data show that the product's visual communication aspect is very good with the criteria of creativity, ideas, and appearance. The creativity of ideas used in products is very good by providing an attractive, original look and following the needs of the times. An attractive media display will make it easier for students to understand the material so that students do not feel bored and can foster enthusiasm for learning (Wibowo & Koeswanti, 2021). In addition, a very good display of products with attractive application designs, clarity and readability of material, appropriate font types and sizes, and using exciting colors. This shows that the design is attractive, the content is proportional, and the typography of the content is not excessive (Arum, 2022).

The software engineering aspect of the products developed in this study is very good with the criteria for learning media installation, learning media operation, and file size. The installation of the developed product is very good; it can be installed on Android, the installation process is easy, it does not interfere with other operating systems, and the application does not bug/errors. This shows that the operation is easy and does not hang (Azmi, 2022). The operation of the product is excellent so that the application is easy to use and the instructions are displayed. According to (Azmi, 2022), media use must be easy and accessible anytime and anywhere so that students are helped in its use. The product file size is categorized as good, and this is because the file size is quite large but still at an average level and does not exceed the size limit of an application.

Conclusion

Android-based AR learning media has been developing on the chemistry of atomic matter. Android-based AR learning media contains a home page, a menu page containing instructions, competencies, materials, AR cameras, quizzes, developers, and exit menus. AR learning media is equipped with AR cards to display 3D objects contained in the database. Android-based AR learning media on the atomic matter can be accessed anytime and anywhere without an internet network. The developed media can be an alternative learning media to help students learn and understand the abstract atomic matter. Media development follows the material presentation, material, language, usefulness, visual communication, and software engineering. The product obtained good validation by material experts and excellent validation by media experts. The teacher's assessment also obtained a very good category. It shows that the media can be used in the learning process. Students' overall response to the product development assessment aspect also obtained a very good category. Thus, Android-based AR development has the potential to be a quality learning medium to help students understand atomic.

Reference

Afrianis, N. & Ningsih, L. 2022. Analisis kesulitan belajar siswa pada materi struktur atom. *Jurnal Pendidikan Kimia dan Terapan*, 6(2):102-108. https://dx.doi.org/10.24014/ konfigurasi.v6i2.18617.

Afriansyah, A. 2018. Rancang bangun media pembelajaran coreldraw berbasis multimedia. *Jurnal Teknologi Informasi dan Komputer Politeknik Sekayu,* 8(1):38-45. https://jurnal.polsky.ac.id/index.php/tips/article/view/113

Arum, A. 2022. Pengembangan Modul Berbasis Augmented Reality Materi Ikatan Kimia untuk Meningkatkan Minat Belajar Siswa SMA/MA Kelas X. *Skripsi*. Yogyakarta: Fakultas Ilmu Tarbiyah dan Keguruan UIN Sunan Kalijaga.

Asnawati. 2019. Upaya peningkatan kemampuan guru untuk menggunakan media pembelajaran dalam proses pembelajaran melalui supervisi akademik Kepala Sekolah SD Negeri 63 Pekanbaru. *Perspektif Pendidikan dan Keguruan,* 10(1):44–58. https://doi.org/10.25299/perspektif.vol10i1.3098.

Azmi, H. 2022. Pengembangan Modul berbasis Augmented reality pada Materi Hidrokarbon. *Skripsi.* Yogyakarta: Fakultas Ilmu Tarbiyah dan Keguruan UIN Sunan Kalijaga.

Chafied, M. 2010. Brosur Interaktif Berbasis Augmented Reality. *Skripsi*. Surabaya: Politeknik Elektronika Negeri Surabaya.

Firdanu, R., Sentot, A., & Suryo. 2020. Pemanfaatan augmented reality sebagai media pembelajaran mengenai peralatan konstruksi dalam dunia pendidikan berbasis android. *Jurnal Mahasiswa Teknik Informatika,* 4(2):276–82. https://doi.org/10.36040/jati.v4i2.2657.

Harahap, A.S. & Jupriyadi. 2020. Pemanfaatan augmented reality (AR) pada media pembelajaran pengenalan komponen elektronika berbasis android. *Jurnal Ilmiah Infrastruktur Teknologi Informasi,* 1(1):20-25. https://doi.org/10.33365/jiiti.v1i1.266.

Hilda, L., Herawati, Lubis, & Raihan. 2021. APMOL: media teknologi geometri molekul berbasis augmented reality dan jmol. Penerbit Samudra Biru, Yogyakarta.

Kholisho, Yosi, N., & Marfuatun. 2018. Implementasi kurikulum 2013 pada SMK di Kabupaten Lombok Timur. *Edumatic: Jurnal Pendidikan Informatika,* 2(2):120-127. https://doi.org/10.29408/edumatic.v2i2.1112.

Kuswanto, J. & Ferri, R. 2018. Media pembelajaran berbasis android pada mata pelajaran sistem operasi jaringan kelas XI. *Jurnal Media Infotama,* 14(1). https://doi.org/10.37676/jmi.v14i1.467.

Lestari, A., Andri, S., & Ali, I. 2020. Pengaruh media pembelajaran berbasis komputer dengan model tutorial untuk meningkatkan hasil belajar siswa pada mata pelajaran TIK. *Jurnal Petik,* 6(1):18–26. https://doi.org/10.31980/jpetik.v6i1.729.

Manasikana, Oktaffi, A., Andri, W., & Andhika. 2022. Keefektifan pembelajaran proyek terhadap keaktifan dan kreativitas mahasiswa mata pembelajaran inovatif IPA materi kimia SMP. *Jurnal Zarah,* 10(1):66–72. https://doi.org/10.31629/zarah.v10i1.4344.

Mawarni, I. 2018. Pengembangan Media Komik Kimia pada Materi Teori Perkembangan Atom di SMA Negeri 7 Banda Aceh. *Skripsi*. Banda Aceh: Fakultas Tarbiyah dan Keguruan Universitas Islam Negeri Ar-Raniry.

Mongilala, M.M., Tulenan, V., & Sugiarso, B.A. 2019. Aplikasi pembelajaran interaktif pengenalan satwa sulawesi utara menggunakan augmented reality. *Jurnal Teknik Informatika,* 14(4):465-474. https://doi.org/10.35793/jti.14.4.2019.27649

Mufida, L., Subandowo, & Gunawan. 2022. Pengembangan e-modul kimia pada materi struktur atom untuk meningkatkan hasil belajar. *Jurnal Ilmiah Penelitian dan Pembelajaran Informatika,* 7(1):138-146. https://doi.org/10.29100/jipi.v7i1.2498.

Nandyansah, W. & Suprapto, N. 2019. Pengembangan media pembelajaran berbasis augmented reality untuk melatihkan keterampilan berpikir abstrak pada materi model atom. *Inovasi Pendidikan Fisika,* 8(2):756–760. https://ejournal.unesa.ac.id/index.php/inovasi-pendidikan-fisika/article/view/28885

Nirwanto, B.G., Murtono, & Fathurrohman. 2021. Media puzzle berbantu augmented reality pada muatan pelajaran IPA tema ekosistem. *Jurnal Edutech Undiksha,* 9(2):275-283. https://doi.org/10.23887/jeu.v9i2.38503.

Oktiarmi, P. 2020. Pengembangan alat peraga kimia sederhana (algatomiokul) pada materi atom, ion dan molekul untuk meningkatkan aktivitas belajar siswa. *Jurnal Guru Dikmen dan Diksus,* 1(1):41–50. https://doi.org/10.47239/jgdd.v1i1.36.

Rahmawati. 2022. Pengembangan Video Animasi Adobe After Effect Berbasis Audiovisual pada Materi Termokimia SMA/MA Kelas XI. *Skripsi*. Yogyakarta: Fakultas Ilmu Tarbiyah dan Keguruan Universitas Islam Negeri Sunan Kalijaga.

Ramadani, R., Ramlawati, R., & Muhammad, A. 2020. Pengembangan modul pembelajaran kimia berbasis augmented reality. *Chemistry Education Review (CER),* 3(2):152-155. https://doi.org/10.26858/cer.v3i2.13766.

El-Ein, A.R.N. & Martadi. 2021. Perancangan augmented reality sebagai media pembelajaran mengenal tata surya di masa pandemi. *Jurnal Barik,* 3(1):195–206. https://ejournal.unesa.ac.id/index.php/JDKV/issue/view/2447

Rikawati, K. & Debora, S. 2020. Peningkatan keaktifan belajar siswa dengan penggunaan metode ceramah interaktif. *Journal of Educational Chemistry (JEC),* 2(2):40-46. https://doi.org/10.21580/jec.2020.2.2.6059.

Rizawayani, Sari, S.A., & Safitri, R. 2017. Pengembangan media poster pada materi struktur atom di SMA Negeri 12 Banda Aceh. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 5(1):127–33. https://jurnal.usk.ac.id/JPSI/article/view/8435

Rohmah, G. 2020. Pengembangan Media Pembelajaran Kimia Berbasis Web "Pintakimia.my.id" untuk Siswa SMA/MA Kelas X Materi Pokok Stoikiometri. *Skripsi*. Yogyakarta: Fakultas Sains dan Teknologi UIN Sunan Kalijaga Yogyakarta.

Ruslan, & Putri, A.M. 2018. Efektivitas alat peraga "karpet kimia" dalam pembelajaran struktur atom dan sistem periodik unsur. *Jurnal Pendidikan Kimia dan Ilmu Kimia (redoks),* 2(1):11–17. https://doi.org/10.33627/re.v2i01.75.

Septian, R. 2019. Sistem Informasi Media Pembelajaran Ms.Word & Excel berbasis Web (Studi Kasus: SMK Binakarya Mandiri). *Skripsi*. Jakarta: Fakultas Teknik Universitas Bhayangkara Jakarta Raya.

Uliontang, Endang, S., & Francisca, H. 2020. Pemanfaatan augmented reality pada media pembelajaran sejarah tentang benda-benda bersejarah peninggalan kerajaan Majapahit di Trowulan Mojokerto. *Teknika: Engineering and Sains Journal,* 4(1):19-26. https://doi.org/10.51804/tesj.v4i1.785.19-26.

Wibowo, Susetyo, A., & Henny, D. 2021. Pengembangan media pembelajaran berbasis komik untuk meningkatkan karakter kemandirian belajar siswa Sekolah Dasar. *Jurnal Basicedu,* 5(6):5100–5111. https://doi.org/10.31004/basicedu.v5i6.1600.

Yaumi, M. 2018. Media dan Teknologi Pembelajaran. Jakarta: Prenadamedia Group.

Yuliono, T., Sarwanto, & Rintayati, P. 2018. Keefektifan media pembelajaran augmented reality terhadap penguasaan konsep sistem pencernaan manusia. *Jurnal Pendidikan Dasar,* 9(1):65-84. https://doi.org/10.21009/JPD.091.06.

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The Contribution of Communication and Digital Literacy Skills to Critical Thinking

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Abstract. The contribution of communication and digital literacy skills to critical thinking in biology are rarely explored. The present study employed a correlational research design to determine how communication and digital literacy skills contributed to students' critical thinking. In this study, communication and digital literacy skills served as the predictor variables, whereas critical thinking served as the criterion variable. Fourth semester students from Tadris Biology department at IAIN Ternate in North Maluku made up the research sample. Essay questions, questionnaires, and observation sheets were used to collect data. Research results show that communication skills and digital literacy simultaneously and significantly affect critical thinking skills. The study's findings proved that communication skills and digital literacy contribute to critical thinking skills as much as 34.93% and 29.67%, respectively. These findings indicate that educators need to incorporate components of communication skills and digital literacy into their instruction in order to enhance students' critical thinking skills.
Keywords: correlation, communication skills, digital literacy, critical thinking skills.

Introduction

Digital literacy is associated with information processing, cognitive, and socio-emotional skills, all of which are critical in assisting pupils in properly carrying out tasks in a digital context (Kaeophanuek et al., 2019). Digital literacy has an essential role in the process of learning, education and society (Saputra & Al Siddiq, 2020). Digital literacy refers to the capacity to explore, retrieve, organize, merge, assess, scrutinize, and amalgamate digital materials, acquire novel insights, generate multimedia representations, and interact with peers within real-life scenarios (Cohen e al., 2020; Fallon, 2020; Marini et al., 2020; McKinstry et al., 2020). Digital literacy can positively affect students' social skills (Mewangi et al., 2020).

Cognitive, technical, and sociological interactions are all linked to digital literacy (Abdelraheem & Ahmad, 2018). The utilization of digital literacy can facilitate learning endeavors in digital communication through the provision of recommendations, contributions, and accounts pertaining to specific educational topics (Lukitasari et al., 2022). Academic achievement and student learning achievement are both influenced by digital literacy (Pagani et al., 2016). The incorporation of digital media in educational settings has the potential to promote enhanced self-efficacy experiences for students, thereby influencing their cognitive processes and self-confidence (Marci-Boehncke & Vogel, 2018). The acquisition of digital literacy skills can facilitate the development of critical thinking abilities among students, thereby enabling them to attain a higher level of maturity and awareness in information creation, communication, and consumption (Yasdin et al., 2021).

Critical thinking begins with asking important questions, clearly formulating information, acquiring relevant information, exploring novel ideas, thinking honestly, and effectively communicating with others (Adeoti & Adeoye, 2012). The ability to identify inferential relationships between various forms of representation, such as statements, concepts, data descriptions, beliefs, judgments, experiences, reasons, information, or opinions, is indicative of the presence of critical thinking. Critical thinking is essential for college students, as it enables them to become discerning consumers of scientific information and make informed decisions in response to various scientific advancements (Pradana et al., 2017).

Critical thinking and communication skills in the classroom can be effectively fostered if students are encouraged to participate in learning and practice problem solving in class (Goel & Chauhan, 2019). Critical thinking plays a significant part in developing human quality. Individuals who possess critical thinking abilities can formulate appropriate inquiries, integrating relevant data, demonstrating productivity and efficacy, exhibiting ingenuity, constructing sound reasoning, and attaining coherent and persuasive outcomes (Carter et.al, 2006). Critical thinking factors develop when students use their critical thinking skills to gather, process, analyze, and respond to information (Fok et al., 2021; Wale & Bishaw, 2020). In information technology, digital literacy may be regarded as a contributing factor that has the potential to impact the critical writing abilities of students, while simultaneously facilitating their productivity and efficacy (Lustyantie et al., 2022). The significance of critical thinking in enhancing student learning outcomes is widely acknowledged. Critical thinking facilitates the assimilation of knowledge through both oral and written communication, while also enhancing the coherence and rationality of language produced (Anjaniputra, 2020).

The utilization of proficient communication abilities can aid in averting instances of misapprehension and miscommunication (Putri et al., 2021). Scientific communication indicators include the ability to obtain information, read scientifically, listen, observe, write scientifically, and present information (Spektor-Levy, 2008). The hallmark of effective communication is the ability to convey information clearly and express thoughts and ideas proficiently through verbal, written, and nonverbal modes. Effective communication also includes the ability to listen meaningfully, interpret to achieve goals, use various media and technology, and convey messages in various situations (Khoerunisa & Habibah, 2020).

The addressee of a message should possess the ability to comprehend the sender's purpose, analyze the contextual background of the message, rectify any misinterpretations, precisely decipher the information conveyed, and determine the appropriate course of action. These abilities are imperative for acquiring knowledge, fostering positive interpersonal connections, creating a sense of belongingness, and attaining career advancement (Velentzas & Borni, 2014). Communication in class must be dynamic and participatory so that students may readily reply, conclude, assess, and contribute comments and suggestions as feedback (Uyen et al., 2021). It is imperative for learners to possess the ability to assimilate recently acquired information and integrate it within a social framework, while also utilizing communication principles to formulate cogent discourse (Mwakapina, 2020).

Past studies rarely explored how communication and digital literacy skills contributed to critical thinking skills, especially in biology learning design courses. This study is essential since it provides an overview of the elements that influence university students' critical thinking skills. The findings of this study can also help instructors reflect on the learning process that has been implemented to increase students' competence in the twenty-first century. Educators can create their own learning designs while empowering students to communicate, think critically, and perform well in digital literacy. The goal of this study was to determine the contribution of communication skills and digital literacy to university students' critical thinking skills.

Methods

The present study employed a correlational research design. Communication skills and digital literacy served as the predictor variables, whereas critical thinking served as the criterion variable. The research population comprised all students from Tadris Biology department, FTIK, IAIN Ternate, North Maluku, Indonesia. The research sample was twenty fourth-semester students from Tadris Biology department, FTIK, IAIN Ternate, North Maluku. This study was conducted in the biology instructional design course during the even semester of the 2021/2022 academic year. A quasi experiment was done before conducting the correlational analysis. This quasi-experimental study used a pretest posttest control group design in which one experimental research class implemented the two stray two stay learning model. The research sample was determined using the purposive sampling technique conducted based on a previous needs analysis.

The research data were gathered using a test administered to the participants from the two stay two stray (experimental) group. The test was conducted before the implementation of the two stay two stray learning model. The test consisted of essay questions to measure students' critical thinking skills. In addition, questionnaires were distributed to assess students' digital literacy and communication skills. Participants' digital literacy and communication skills were also observed during the implementation of the two stay two stray learning model by the lecturer. The observations were done using an observation sheet. Participants were given a test of their critical thinking skills at the conclusion of fourteen face-to-face class meetings. After implementing the two stay, two stray learning model, questionnaires on digital literacy and communication skills were distributed. ANOVA was utilized to conduct descriptive and inferential data analysis techniques. The multiple linear regression analysis was also done using ANOVA.

Research instruments included instruments used to collect data on communication skills, digital literacy, and critical thinking skills. The instruments used to measure participants' digital literacy consisted of observation sheets and a questionnaire. These instruments were developed based on aspects of 1) internet searching, 2) hypertextual navigation, 3) content evaluation, and 4) knowledge assembly. The instruments used to evaluate participants' communication skills were a questionnaire and an observation sheet. These instruments contained indicators of speaking, listening, writing, and nonverbal communication. Essay questions were used to assess participants' critical thinking skills. Before use, the instruments were subjected to expert and empirical validation. The research data were gathered by distributing the questionnaires and essay questions, as well as conducting class observations. Multiple linear regression analysis with SPSS was employed in data analysis.

Results and Discussion

A multiple linear regression analysis was used to investigate the contribution of independent variables, X1 and X1, to the dependent variable Y. Table 1 summarizes the results of a multiple linear regression analysis using ANOVA.

Table 1. ANOVA on the contribution of communication skills (x1) and digital literacy (x2) to critical thinking skills (y)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	929.800	2	464.900	16.435	.000[b]
	Residual	509.182	18	28.288		
	Total	1438.982	20			

a. dependent variable: critical thinking skills (y)

b. predictors: (constant), digital literacy (x2), communication skills (x1)

Table 2 shows an F-calculated of 16.435 and a significance level of 0.000. A significance level smaller than 0.05 indicates that variables X1 and X2 had a simultaneous contribution to Y. Therefore, it can be concluded that communication skills and digital literacy simultaneously and significantly affect critical thinking skills. The acquisition of communication skills and digital literacy skills is known to exert a favorable impact on the enhancement of critical thinking skills among students. According to Han et al. (2019), there exists a positive correlation between communication skills, critical thinking skills, self-confidence, curiosity, and problem-solving abilities. The cultivation of higher order thinking skills (HOTS) can be facilitated through the provision of instruction that prompts students to engage in critical and creative thinking, as well as problem solving (Panggabean et al., 2021). The capacity to engage in critical thinking when comprehending concepts is positively correlated with the capacity to establish connections among interrelated concepts. Critical thinking is also demonstrated by the ability to access information. According to Supriyanti et al. (2020), the availability of information has the potential to enhance knowledge, diminish uncertainty, and enhance reasoning abilities. Sasson (2018) has identified that a limitation to the improvement of literacy rates is the employment of singular information sources in learning processes. The acquisition of critical thinking can be influenced by one’s possession of information and digital literacy. According to Leaning (2019), students’ abilities to critically evaluate information and discern credible sources enable them to exercise greater selectivity and employ their analytical faculties in acquiring information. Literacy is also perceived as a tool that can be utilized to obtain and disseminate information (Rahman et al., 2019).

Table 2. The regression coefficient of communication skills and digital literacy on critical thinking skills

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations		
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part
1	(Constant)	11.169	10.769		1.037	.313			
	Communication Skills (X1)	.128	.042	.494	3.070	.007	.707	.586	.430
	Digital Literacy (X2)	.238	.087	.437	2.722	.014	.679	.540	.382

a. dependent variable: critical thinking skills (y)

Table 2 reveals the regression equation for communication skills (X1), digital literacy (X2), and critical thinking skills (Y): $Y = 11.169 + 0.128 X_1 + 0.238 X_2$.

Based on the regression equation, it is known that:

a. if X1 and X2 equal 0 (zero), then Y is 11.169.
b. X1 has a positive (unidirectional) effect on Y, where one unit increase in X1 results in 0.128 increase in Y, and vice versa.
c. X2 has a positive (unidirectional) effect on Y, where one unit increase in X2 results in 0.238 increase in Y and vice versa.

The findings suggest a positive correlation between students' critical thinking skills and their communication and digital literacy skills, with respective coefficients of 0.128 and 0.238. Digital media significantly facilitates the enhancement of students' communication skills. Digital media can serve as a valuable resource for students in various educational contexts, such as presentations, studies, discussions, and problem olving activities (Rahman et al., 2019). Communication skills encompass the capacity to effectively convey ideas through both verbal and written means, as well as the ability to articulate viewpoints, provide coherent directives, and inspire others through speech (Mishra & Mehta, 2017). Possessing effective communication skills can aid in the prevention of misunderstandings and miscommunication (Mahajan, 2015). Effective communication skills play a crucial role across various domains (Putri et al., 2021). The evaluation of digital literacy is contingent upon the extent to which students can utilize cognitive frameworks in both academic and non-academic contexts. The concept of digital literacy encompasses the ever-changing technological landscape and necessitates responsible access to information contributions (Meyers et al., 2013).

In the age of globalization, students must cultivate digital literacy. This competency can increase students' digital knowledge and motivation to pursue information from different reference sources (Amin et al., 2023). Students with high levels of digital literacy can acquire the information or knowledge they require because they can use digital media more selectively. Digital literacy contributes to an increase in students' ability to argue in each and every response or statement (Darmaji et al., 2023). The submission of evidence, such as examples or data, can support an argument. Using their digital literacy skills, students can utilize their learning experiences to comprehend a piece of information (Hilala et al., 2023). The use of technology in education has a positive effect on learning, including making learning more effective and evaluation and assessment more adaptable because they can be conducted from anywhere (Putri & Asrizal, 2023).

Students need to develop their critical thinking skills in order to meet the challenges of the twenty-first century (Marlina et al., 2022). By paying attention to the characteristics and potential of the students' learning environment, critical thinking skills can be enhanced (Hanum et al., 2023). Teachers need to promote learning activities that can stimulate students' critical thinking and communication skills dan train students' ability to solve problems, become independent, and be more disciplined (Bahtiar et al., 2023). Critical thinking not only aids in the acquisition of knowledge, but also in the application of knowledge when searching for a solution to a problem (Istiqomah et al., 2022). Learners from a variety of social, cognitive, and personality backgrounds should be able to cultivate active learning environments in which they can communicate expansively in order to comprehend topics (Amin et al., 2022a).

Teachers must pose questions that activate students' prior knowledge and help them focus their learning efforts and assess their knowledge (Amin et al., 2022b). Students require higher-level reasoning skills not only during examinations, but also throughout the learning process (Fitri et al., 2021). Critical thinking is also associated with cognitive skills because it entails problem-solving activities (Musliman & Damayanti, 2023) Critical thinking is beneficial for comprehending the interaction of factors that influence results and calculating various possibilities and scenarios in order to make the best decision. Students must possess 21st century skills such as critical thinking skills in order to face global challenges (Wati & Syafriani, 2023).

The results of the multiple regression analysis on communication skills, digital literacy, and critical thinking skills presents a determination coefficient (R-squared) of 0.646, suggesting that 64.6% of Y are influenced by X1 and X2, while the remaining 35.4% are influenced by other factors. In other words, the simultaneous contribution of communication skills (X1) and digital literacy (X2) on critical thinking skills (Y) is 64.6%. Individuals with critical thinking skills are capable of drawing inferences from a wide range of information, adeptly utilizing said information to address a given problem, and effectively identifying pertinent sources to facilitate problem-solving (Haryanto et al., 2020). The term "critical thinking" encompasses the ability of students to utilize acquired information to make informed decisions and effectively communicate their thoughts through reflection and logical reasoning. Critical thinking is a skill that involves reflective evaluation, analysis, and utilization of pertinent information within a specific context through effective communication (Gut, 2011). Individuals who possess competencies in communication, collaboration, critical thinking, problem solving, creativity, and innovation within their field of expertise are likely to achieve greater success in higher education, professional settings, and within the broader community (Wrahatnolo & Munoto, 2018). Based on the figures presented in Table 3, the effective contribution (EC) was calculated using the formula: EC = Beta x Zero Order.

Table 3. The contribution of communication skills and digital literacy on critical thinking skills

Variable	RC (%)	EC (%)
Communication Skills (X1)	54.07	34.93
Digital Literacy (X2)	45.93	29.67
Total	100	64.60

Communication skills (X1) and digital literacy (X2) make up 34.93% and 29.67% of the effective contribution to critical thinking skills (Y), respectively. Critical thinking skills are inextricably connected to information literacy. Critical thinking skills are necessary for investigating and assessing information in order to generate opinions based on relevant and reliable data (Crist et al, 2017). The capacity to obtain information also demonstrates critical thinking. Information broadens knowledge, eliminates uncertainty, and improves thinking abilities. Students with strong information literacy will be able to use a variety of sources of information, as well as analyze and evaluate material more comprehensively (Subekti, et al, 2018). Reading habits have a favorable impact on critical thinking abilities (Taglieber, 2000).

Answering questions demonstrates pupils' ability to think critically (Trisdiono et al., 2019). Learning environment and enthusiasm in learning enhance critical thinking skills (Erwiza, 2019). Digital information and media are available everywhere, allowing students to readily, rapidly, and in enormous quantities access to content. As a result, educators must continue to seek to develop learning methodologies that can help students absorb information critically (Dimmit, 2017). Critical thinking also includes the ability to synthesize and filter numerous arguments and information so that it may be accepted correctly (Syafaren, 2019).

Multidisciplinary instruction has the potential to facilitate the integration and amalgamation of knowledge from a variety of perspectives, thereby augmenting students' capacity for analytical reasoning. Students may investigate and analyze various forms of material by developing critical thinking skills (Supriyanti et al., 2020). Literacy is extremely beneficial to students in terms of developing communication skills, the capacity to work in a variety of teams, cooperate, and form interpersonal relationships. Students with these skills can always position themselves in harmonious interactions (Setiyadi et al., 2022). Students with sufficient digital literacy can detect the risks and negative impacts of using the internet or online resources (Helsper & Smahel, 2020; Ruenphongphun, 2021).

Good reasoning assists in the comprehension of information, the transmission of information, and the exchange of information from information sources. In other words, there is a relationship between reasoning skill and communication ability (Makur, 2019). Communication skills have an essential place in teamwork to create a collaborative environment that requires team spirit (Kereluik et al., 2013). Communication is required to promote science process skills, which include how students explain an item, event, action, and discussion findings using words, symbols, drawings, and figures or tables (Omeodu et al., 2021). Students must use verbal communication to communicate their findings and views orally through oral presentations, discussions, and debates. Students' verbal communication skills might also predict their writing test scores (Haworth & Garrill, 2003).

Digital literacy in educational settings encompasses more than mere technical proficiency with digital tools. It entails the capacity to effectively navigate and evaluate information, engage in critical thinking, and exhibit appropriate conduct in online environments (Tang & Chaw, 2016). Digital literacy contains several elements such as critical thinking skills, creativity, the ability to build and evaluate information, the ability to use digital media effectively, and the ability to develop digital writing results (Al-Qallaf & Al-Mutairi, 2016). The dynamism and entertainment value of classroom learning can be enhanced through the acquisition of digital literacy by students. In summary, the acquisition of digital literacy is crucial for students' academic progress, as it enables them to engage in critical discourse on significant issues pertaining to technology utilization (Khan et al., 2022). Furthermore, according to Hague (2010), digital literacy encompasses the capacity to proficiently generate, collaborate, and communicate, while also comprehending the optimal utilization of digital technology to facilitate these activities. Individuals possessing this aptitude are commonly receptive and flexible in response to alterations.

Research has found a relationship between digital literacy and high to moderate creative self-concept (Alsoud et al., 2021; Alt & Raichel, 2020). Digital literacy contributes to meeting students' learning demands and their future professional needs (Tham et al., 2021). A person is said to be able to think critically if s/he can put experience to the test, appraise information and ideas, and evaluate prior arguments (Mezirow, 1998). Individuals who are digitally literate have the technical knowledge and abilities required to use, access, and analyze technological information to create digital information, as well as to use online networks for communication, socialization, and learning (Ustundag et al., 2017). Therefore, digital literacy should not be seen as only "using technology". Social and cognitive abilities are also required for digital literacy (van Laar et al., 2017).

Students must gain digital literacy to obtain 21st century abilities (Yasa & Arnelia, 2023). The five components of digital literacy are 1) identifying, finding, retrieving, storing, organizing, and analyzing digital information, 2) communicating in a digital environment and being able to interact in communities and networks, 3) creating and editing new content, integrating and redefining prior knowledge, and generating creative expression from media output, 4) identifying digital needs and resources, and 5) effectively and creatively using technology to solve conceptual problems through digital means (Phuapan et al, 2016). Digital learning is more effective than traditional learning in enhancing student motivation and achievement (Lin et al., 2017). The integration of digital literacy into learning resources can enhance the overall quality of students' education (Scanlon, 2000). Digital media is important in education because it can present culturally, visually, and audibly engaging and participatory learning content (Rusydiyah, 2020). Students' creativity will suffer if they do not understand the fundamental concepts of the technology they own (Gomez-Trigueros et al., 2019).

Conclusion

The results of the data analysis and the research discussion reveal the contribution of communication skills and digital literacy to critical thinking skills. Communication skills and digital literacy make up 34.93 and 29.67% of the effective contribution to critical thinking skills, respectively. According to the findings of this study, communication skills and digital literacy are factors that affect critical thinking skills. As a result, educators must design learning to enhance students' critical thinking skills. It is recommended that future researchers conduct a more in-depth study on the importance of communication skills and digital literacy to critical thinking skills, with a larger number of research samples and a longer research duration.

References

Abdelraheem, A.Y. & Ahmed, A.M. 2018. The impact of using mobile social network applications on students' social-life. *International Journal of Instruction*, 11(2):1-14. https://doi.org/10.12973/iji.2018.1121a.

Adeoti, Y.F. & Adeoye, E.A. 2012. Developing critical thinking and communication skills in students: implications for practice in education. *African Research Review,* 6(1):311-324. http://dx.doi.org/10.4314/afrrev.v6i1.26.

Al-Qallaf, C.L. & Al-Mutairi, A.S.R. 2016. Digital literacy and digital content support learning. *The Electronic Library*. https://doi.org/10.1108/el-052015-0076.

Alsoud, A.R., Al-Debei, M.M., Johar, M., Ab Yajid, M.S., Alshareef, H.N., & Ariffin, I. 2021. Digitalization in educational technologies for edtech solutions: a comparatuive study of jordanian and malaysian universities. *Educational Sciences: Theory & Practice*, 21(4):83-99. https://jestp.com/index.php/estp/article/view/1502/816.

Alt, D. & Raichel, N. 2020. Enhancing perceived digital literacy skills and creative self-concept through gamified learning environments: insights from a longitudinal study. *International Journal of Educational Research*, 101(101561). https://doi.org/10.1016/j.ijer.2020.101561.

Amin, A.M., Karmila, F., Laode, Z.A., Ermin. E., Akbar, A.Y., & Ahmed, M.A. 2023. The WE-ARe model's potential to enhance digital literacy of preservice biology teachers. *JPBI (Jurnal Pendidikan Biologi Indonesia*), 9(1):36-45. https://doi.org/10.22219/jpbi.v9i1.23061.

Amin, A.M., Karmila, F., Pantiwati, Y., Adiansyah, R., & Yani, A. 2022a. The communication skills profile of pre-service biology teachers. *Jurnal Penelitian Pendidikan IPA*, 8(4):2109–2115. https://doi.org/10.29303/jppipa.v8i4.1825.

Amin, A.M., Ahmad, S.H., Zulkarnaim., & Adiansyah, R. 2022. RQANI: A learning model that integrates science concepts and islamic values in biology learning, 15(3):695-718. https://doi.org/10.29333/iji.2022.15338a.

Anjaniputra, A.G. 2020. Prevalence of tertiary level students' critical thinking skills in speaking. *International Journal of Education*, 13(1):18-25. doi: 10.17509/ije.v13i1.18196.

Bahtiar, Maimun, & Ibrahim. 2023. Analysis of collaboration, communication, critical thinking, and creative thinking ability of students in solving science problems in terms of gender. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):379-400. doi.org/10.24815/jpsi.v10i4.29065.

Carter, L., Rukholm, E., Mossey, S., Dresler, G.V., Baker, D., & Sheehan, C. 2006. Critical thinking in the online nursing education setting: rasing the bar. *Canadian Journal of University Continuing Education*, 32(1):27-46. https://doi.org/10.21225/D5BS38.

Crist, C.A., Duncan, S.E., & Bianchi, L.M. 2017. Incorporation of cross-disciplinary teaching and a wiki research project to engage undergraduate students to develop information literacy, critical thinking, and communication skills. *Journal of Food Science Education*, 16(3):81-91. https://doi.org/10.1111/1541-4329.12111.

Cohen, R., Parmentier, A., Melo, G., Sahu, G., Annamalai, A., Chi, S., & Sakhuja, S. 2020. Digital literacy for secondary school students: using computer technology to educate about credibility of content online. *Creative Education*, 11(05):674-692. https://doi.org/10.4236/ce.2020.115050.

Darmaji, Astalini, Kurniawan, D.A., & Prameswari, N. 2023. Analysis science process skills, arnguing ability and digital literacy of MAN 5 Batanghari students based on gender differences. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):221-235. https://doi.org/10.24815/jpsi.v11i2.27678.

Dimmitt, N. 2017. The power of project-based learning: experiential education to develop critical thinking skills for university students. *In CBU International Conference Proceedings*, 5:575-579. https://doi.org/10.12955/cbup.v5.988.

Erwiza, E., Kartiko, S., & Gimin, G. 2019. Factors affecting the concentration of learning and critical thinking on student learning achievement in economic subject. *Journal of Educational Sciences*, 3(2):205-215. http://dx.doi.org/10.31258/jes.3.2.p.205-215.

Falloon, G. 2020. From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 68(5):1-24. https://doi.org/10.1007/s11423-02009767-4.

Fithri, S., Pada, A.U.T., Artika, W., Nurmaliah, C., & Hasanuddin. 2021. Implementasi LKPD berbasis STEM untuk meningkatkan keterampilan berpikir kritis peserta didik. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 9(4):555-564. https://doi.org/10.24815/jpsi.v9i4.20816.

Fok, L.Y., Morgan, Y.C., & Zee, S.M. 2021. A multi-industry study of sustainability, total quality management, organizational culture, and performance. *International Journal of Operations and Quantitative Management*, 27(1):45-60. https://doi.org/10.46970/2021.27.1.3.

Goel, N. & Chauhan, S. 2019. Rolling a role: enhancing critical thinking and communication skills. *Literacy Information and Computer Education Journal,* 10(1):3114-3118. Doi: 10.20533/licej.2040.2589.2019.0408.

Gómez-Trigueros, I.M., Ruiz-Bañuls, M., & Ortega-Sanchez, D. 2019. Digital literacy of teachers in training: moving from ICTS (information and communication technologies) to LKTS (learning and knowledge technologies). *Education Sciences*, 9(274):1-10. doi:10.3390/ educsci9040274.

Gut, D.M. 2011. Integrating 21st century skills into the curriculum. In G. Wan & D.M. Gut (Eds.), Bringing schools into the 21st century (pp.137-157). Dordrecht, the Netherlands: Springer.

Hague, C. & Payton, S. 2011. Digital literacy across the curriculum. *Curriculum Leadership,* 9(10) https://www.semanticscholar.org/paper/Digital-literacy-across-the curriculum-HaguePayton/35c81071e79dad22cea0460481869bb4536536de.

Han, J., Ahn, E., & Hwang, J. 2019. Effects of critical thinking and communication skills on the problem-solving ability of dental hygiene students. *Journal of Dental Hygiene Science,* 19(1):31-38. https://doi.org/10.17135/jdhs.2019.19.1.31.

Hanum, L., Hasan, M., Pada, A.U.T., Rahmatan, H., Rahmayani, R.F.I., Elisa, & Yusrizal. 2023. Development of learning devices based on ethnoscience-project based learning to improve students' critical thinking skills. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):288-305. https://doi.org/10.24815/jpsi.v11i2.28294.

Haryanto, H., Ghufron, A., & Suyantiningsih, S., & Kumala, F.N. 2020. The correlation between digital literacy and parents' roles towards elementary school students' critical thinking. *Cypriot Journal of Educational Science,* 17(3):828-839. https://doi.org/ 10.18844/cjes.v17i3.6890.

Haworth, I.S. & Garrill, A. 2003. Assessment of verbal communication in science education a comparison of small and large classes. *The International Union of Biochemistry and Molecular Biology*, 31(1):24–27. Doi: 10.1002/bmb.2003.494031010164.

Helsper, E.J. & Smahel, D. 2020. Excessive internet use by young europeans: psychological vulnerability and digital literacy? *Information, Communication & Society*, 23(9):1255–1273. https://doi.org/10.1080/1369118x.2018.1563203.

Hilala, R., Laliyo, L.A.R., Kilo, J.L., Tangio, J., Mohammad, E., & Sihaloho, M. 2023. Scientific argumentation skills in explaining phenomena related to acid-base concepts. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):360-378. DOI: doi.org/10.24815/jpsi.v10i4.27822.

Istiqomah, N., Hujjatusnaini, N., Septiana, N., & Amin, A.M. 2022. Implementasi model pembelajaran project based learning terintegrasi praktikum studi antagonisme *Escherichia coli* dan *Candida albicans* terhadap keterampilan berpikir kritis mahasiswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 10(4):892-904. DOI: doi.org/10.24815/jpsi.v10i4.26281.

Kaeophanuek, S., Na-Songkhla, J., & Nilsook, P. 2019. A Learning process model to enhance digital literacy using critical inquiry through digital storytelling (CIDST).

International Journal of Emerging Technologies in Learning, 14(3):22-37. https://doi.org/10.3991/ijet.v14i03.8326.

Kereluik, K., Mishra, P., Fahnoe, C., & Terry, L. 2013. What knowledge is of most worth: teacher knowledge for 21 st century learning. *Journal of Digital Learning in Teacher Education*, 29(4):127–140. https://doi.org/10.1080/21532974.2013.10784716.

Khan, N., Sarwar, A., Chen, T.B., Khan, S. 2022. Connecting digital literacy in higher education to the 21st century workforce. *Knowledge Management & E-Learning*, 14(1):45-61. https://doi.org/10.34105/j.kmel.2022.14.004.

Khoerunisa, E., & Habibah, E. 2020. Profil keterampilan abad 21 (21st century soft skills) pada mahasiswa. *Iktisyaf: Jurnal Ilmu Dakwah Dan Tasawuf*, 2(2):55-68. DOI: 10.53401/iktsf.v2i2.20.

Leaning, M. 2019. An approach to digital literacy through the integration of media and information literacy. *Media and Communication*, 7(2):4-13. https://doi.org/10.17645/mac.v7i2.1931.

Lin, M.H., Chen, H.C., & Liu, K.S. 2017. A study of the effects of digital learning on learning motivation and learning outcome. *Eurasia Journal of Mathematics, Science and Technology Education,* 13(7):3553-3564. doi:10.12973/eurasia.2017.00744a.

Lukitasari, M., Murtafiah, W., Ramdiah, S., Hasan, R., & Sukri, A. 2022. Constructing digital literacy instrument and its effect on college students' learning outcomes. *International Journal of Instruction*, 15(2):171-188. https://doi.org/10.29333/iji.2022.15210a.

Lustyantie, N., Suriyati, Y., Isnan, F., Ramli, N., Yudha, R.P. 2022. The Effect of cognitive style, critical thinking, and digital literature on argumentative writing skills. *Educational Sciences: Theory and Practice*, 22(1):27-35. http://dx.doi.org/10.12738/jestp.2022.1.0003.

Mahajan, R. 2015. The key role of communication skills in the life of professionals. IOSR *Journal of Research & Method in Education* (IOSRJRME), 20(12):36-39. https://doi.org/10.9790/0837-201223639.

Makur, A.P. 2019. The influence of PQ4R strategy and mathematical reasoning ability towards mathematical communication skills. *SJME (Supremum Journal of Mathematics Education)*, 3(1):18-31. https://doi.org/10.35706/sjme.v3i1.1467

Marci-Boehncke, G. & Vogel, T. 2018. Digital literacy and inclusion: The impact of theory and practice in teachers' education. *INTED2018 Proceedings. Valencia: IATED Academy,* p.6872-6879. DOI: 10.21125/inted.2018.1618

Marlina, L., Paramitha, G.P., & Sriyanti, I. 2022. Development of electronic modules based on critical thinking skills on vibration, waves, and sound materials for junior high school students. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education),* 10(2):324-354. https://doi.org/10.24815/jpsi.v10i2.23844.

Marini, S., Hanum, F., & Sulistiyo, A. 2020. Digital literacy: empowering Indonesian women in overcoming digital divide. In 2nd International Conference on Social Science and Character Educations (ICoSSCE 2019), p.137-141. Atlantis Press. https://doi.org/10.2991/assehr.k.200130.029.

McKinstry, C., Iacono, T., Kenny, A., Hannon, J., & Knight, K. 2020. Applying a digital literacy framework and mapping tool to an occupational therapy curriculum. *Australian Occupational Therapy Journal*, 67(3):210-217. https://doi.org/10.1111/1440-1630.12644.

Mewangi, A.B., Purnomo, A., & Ginanjar, A. 2020. Pengaruh literasi digital terhadap keterampilan sosial dalam pembelajaran IPS pada peserta didik kelas IX SMP Islam Al azhar 29 Semarang. *Harmony,* 5(1):40-46. http://journal.unnes.ac.id/sju/index.php/ harmony.

Meyers, E.M., Erickson, I., & Small, R.V. 2013. Digital literacy and informal learning environments. *An Introduction, Learning, Media and Technology*, 38(4):355-367. DOI: 10.1080/17439884.2013.783597.

Mezirow, J. 1998. On critical reflection. *Adult Education Quarterly*, 48(3):185-198. https://doi.org/10.1177/074171369804800305.

Mishra, P. & Mehta, R. 2017. What we educators get wrong about 21 century learning: results of a survey. *Journal of Digital Learning in Teacher Education*, 33(1):6-19. DOI: 10.1080/21532974.2016.1242392.

Musliman, A. & Damayanti, F. 2023. Use of science process skills indicators in "avicom" science creativity competition to improve student critical thinking. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(2):236-250. DOI: doi.org/10.24815/jpsi.v10i4.27696.

Mwakapina, J.W. 2020. Communication skills course in bridging the gap of weak students' communicative competence and accentuating performance: a case of sokoine university of agriculture. *International Journal of Language and Linguistics*, 8(1):1-10. doi: 10.11648/j.ijll.20200801.11.

Omeodu, M.D., Oduh., & Nathaniel, V.A. 2021. Significance of field trip on biology students acquisition of science process skills in abua odual local government area. *International Journal of Innovative Social & Science Education Research*, 9(1):37–45. https://seahipaj.org/journals-ci/mar-2021/IJISSER/full/IJISSER-M-4-2021.pdf.

Pagani, L., Argentin, G., Gui, M., & Stanca, L. 2016. The impact of digital skills on educational outcomes: evidence from performance tests. *Educational Studies*, 42(2):137-162. https://doi.org/10.1080/03055698.2016.1148588.

Panggabean, F.T.M., Pardede, P.O., Sitorus, R.M.D., Situmorang, Y.K., Naibaho, E.S., & Simanjuntak, J.S. 2021. Application of 21st century learning skills oriented digital-age literacy to improve student literacy HOTS in science learning in class IX

SMP. *Jurnal Mantik,* 5(3):1992-1930. https://iocscience.org/ejournal/index.php/mantik/article/view/1796/1384.

Phuapan, P., Viriyavejakul, C., & Pimdee, P. 2016. An analysis of digital literacy skills among thai university seniors. *International Journal of Emerging Technologies in Learning (iJET)*, 11(3):24-31. https://doi.org/10.3991/ijet.v11i03.5301.

Putri, R.K., Bukit, N., & Simanjuntak, M.P. 2021. The effect of project based learning model's on critical thinking skills, creative thinking skills, collaboration skills, & communication skills (4C) physics in senior high school. *Advances in Social Science, Education and Humanities Research*, 591, p.323-330. Doi: 10.2991/assehr.k.211110.103.

Putri, R.M. & Asrizal. 2023. Need analysis of developing digital teaching materials to improve 21st century skills. *JIPI (Jurnal IPA dan Pembelajaran IPA),* 7(2):108-117. DOI: dx.doi.org/10.24815/jipi.v7i2.29797.

Rahman, Sopandi, W., Widya, R.N., & Yugafiat, R. 2019. Literacy in the context of communication skills for 21st century teacher education in primary school students. *International Journal of Science and Applied Science: Conference Series,* 3(1):101-108. https://doi.org/10.20961/ijsascs.v3i1.32462.

Ruenphongphun, P., Sukkamart, A., & Pimdee, P. 2021. Thai undergraduate digital citizenship education skills: A second-order confirmatory factor analysis (CFA). World *Journal on Educational Technology: Current Issues*, 13(3):370-385 https://doi.org/10.18844/wjet.v13i3.5937.

Rusydiyah, E.F., Purwati, E., & Prabowo, A. 2020. How to use digital literacy as a learning resource for teacher candidates in Indonesia. *Cakrawala Pendidikan,* 39(2):305-318. doi:10.21831/cp.v39i2.30551.

Saputra, M., & Al Siddiq, I.H. 2020. Social media and digital citizenship: the urgency of digital literacy in the middle of a disrupted society era. *International Journal of Emerging Technologies in Learning*, 15(7):156-161. https://doi.org/10.3991/IJET.V15I07.13239.

Scanlon, E., Jones, A., Barnard, J., Thompson, J., & Calder, J. 2000. Evaluating information and communication technologies for learning. *Educational Technology and Society*, 3(4):101-107. doi:10.1016/j.sbspro.2009.01.375.

Setiyadi, D., Fortuna, D., & Ramadhan, A. 2022. Pemanfaatan video kreatif dan media sosial youtube sebagai media pembelajaran matematika kelas tinggi. *Dawuh Guru: Jurnal Pendidikan MI/SD,* 2(1):31-42. https://doi.org/https://doi.org/10.35878/guru.v2i1.344.

Spektor-levy, O., Eylon, B., & Scherz, Z. 2008. Teaching communication skills in science : tracing teacher change. *Teaching and Teacher Education*, 24:462–477. https://doi.org/10.1016/j.tate.2006.10.009.

Subekti, H., Taufiq, M., Susilo, H., Ibrohim, & Suwono, H. 2018. Mengembangkan literasi informasi melalui belajar berbasis kehidupan terintegrasi stem untuk menyiapkan calon guru sains dalam menghadapi era revolusi industri 4.0: review literatur. *Education and Human Development Journal*, 3(1):81-90. https://doi.org/10.33086/ehdj.v3i1.90.

Supriyanti, S., Permanasari, A., & Khoerunnisa, F. 2020. Correlation between information literacy and critical thinking enhancement through PjBL-information literacy learning model. *Journal of Educational Science,* 4(4):774-784. https://doi.org/10.31258/jes.4.4.p.774-784.

Syafaren, A., Yustina, Y., Mahadi, I., & Vebrianto, R. 2019. Increasing critical thinking skills through natural science learning based on the integration of guided inquiry with numbered heads together. *Journal of Educational Sciences*, 3(3):433-444. DOI: http://dx.doi.org/10.31258/jes.3.3.p.433-444.

Taglieber, L.K. 2000. Critical reading and critical thinking the state of the art. *Ilha do Desterro A Journal of English Language, Literatures in English and Cultural Studies*, (38):015-037. https://periodicos.ufsc.br/index.php/desterro/article/view/8263.

Tang, C.M., & Chaw, L.Y. 2016. Digital literacy: a prerequisite for effective learning in a blended learning environment? *Electronic Journal of ELearning*, 14(1):54-65. https://files.eric.ed.gov/fulltext/EJ1099109.pdf.

Tham, J.C.K., Burnham, K.D., Hocutt, D.L., Ranade, N., Misak, J., Duin, A.H., Campbell, J.L. 2021. Metaphors, mental models, and multiplicity: understanding student perception of digital literacy. *Computers and Composition*, 59:102628. https://doi.org/10.1016/j.compcom.2021.102628.

Trisdiono, H., Siswandari, S., Suryani, N., & Joyoatmojo, S. 2019. Development of multidisiplin integrated project-based learning model to improve critical thinking and cooperation skills. *JPI (Jurnal Pendidikan Indonesia),* 8(1):9-20. https://doi.org/10.23887/jpi-undiksha.v8i1.17401.

Ustundag, M.T., Gunes, E., & Bahcivan, E. 2017. Turkish adaptation of digital literacy scale and investigating pre-service science teachers' digital literacy. *Journal of Education and Future*, (12):19-29. https://dergipark.org.tr/tr/download/article-file/332115.

Uyen, B.P., Tong, D.H., & Tram, N.T.B. 2021. Developing mathematical communication skills for students in grade 8 in teaching congruent triangle topics. *European Journal of Educational Research,* 10(3):1287-1302.https://doi.org/10.12973/eujer.10.3.1287.

Van Laar, E., van Deursen, A.J.A.M., van Dijk, J.A.G.M., & de Haan, J. 2017. The relation between 21st century skills and digital skills: a systematic literature review. *Computers in Human Behavior*, 72:577–588. https://doi.org/10.1016/j.chb.2017.03.010.

Velentzas, J.O.H.N., & Broni, G. 2014. Communication cycle: definition, process, models and examples. Recent advances in financial planning and product Development. *Proceedings of the 5th International Conference on Finance, Accounting and Law (ICFA '14)*, Istanbul, Turkey, 15-17 December 2014, p.117-131.

Wale, B.D., & Bishaw, K.S. 2020. Effects of using inquiry-based learning on EFL students' critical thinking skills. *Asian-Pacific Journal of Second and Foreign Language Education*, 5(1):1-14. https://doi.org/10.1186/s40862-020-00090-2.

Wati, W.W. & Syafriani. 2023. Validity of physics e-modules based on an inquiry model integrated with the science, environment, technology, and society approach to 21st century skills. *JIPI (Jurnal IPA dan Pembelajaran IPA),* 7(2):133-144. DOI: dx.doi.org/10.24815/jipi.v7i2.30002.

Wrahatnolo, T., & Munoto. 2018. 21st centuries skill implication on educational system. *IOP Conf. Series: Materials Science and Engineering*, 296(012036). doi:10.1088/1757-899X/296/1/012036.

Yasa, A.D., & Rahayu, S. 2023. A Survey of elementary school students digital literacy skills in science learning. *AIP Conference Proceeding, 2569,* 060015. https://doi.org/10.1063/5.0113483.

Yasdin, Y., Yahya, M., Yusuf, A.Z., Musa, M.I., Sakaria, S. & Yusri, Y. 2021. The role of new literacy and critical thinking in students' vocational development. *Cypriot Journal of Educational Science*, 16(4):1395-1406. https://doi.org/10.18844/cjes.v16i4.5991.