
Development of Student Worksheets Based on Science, Technology, Engineering, and Mathematics on the Material of the Human Digestive System for Class XI High School Students

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Abstract. The reality in the field shows that teachers have not yet fully utilized learning media in conducting lessons, and the student worksheets (LKPD) developed by the teachers are also not yet optimal. The purpose of this study is to develop a STEM-based LKPD learning media that is worthy, practical, and effective in the teaching and learning process. Field tests of validation and reliability of assessment instruments were carried out at high school students. Tahfizil qur'an yayasan islamic center sumatera utara in june 2024 by class XI-IPA students with 35 respondents. The method used in this study is the research and development method with the ADDIE model. The stages of the ADDIE model are analysis (analyzing), namely analyzing the learning needs of students and teachers. The design stage (designing), namely designing the product. The development stage (developing), namely the realization of making LKPD using canva and validation (1 lecturer expert in learning media, 1 lecturer expert in subject matter and 1 expert field practitioner (biology teacher)). The implementation stage (implementing), namely applying the media to students so that they know the feasibility of the product, the practicality of the product and the effectiveness to determine the level of students conceptual understanding in using the product as a teaching material. Based on the results and discussion of STEM-based LKPD on the human digestive system for class XI high school students, it is known that the feasibility of the media is measured through the results of the media expert validation assessment, namely 91,57% (very worthy), material experts, namely 98,6% (very worthy) and field practitioner experts (biology teachers) namely 85% (very worthy). Then, the practicality of the media is measured using a student response questionnaire, namely 82,56% (very practical). Meanwhile, the effectiveness test of the N-gain score product is 0,82 with an N-gain value > 0,7 in the high category and the treatment criteria using LKPD are effective.

Keywords: LKPD, STEM, Human Digestive System

Introduction

Education is very important for 21st century skills that play an important role for students to solve a problem appropriately. Law No. 20 of 2003 has regulated education as an effort to realize awareness through planning the learning process and learning atmosphere, so that it can actively develop the potential of students. This includes the power of self-awareness, religious spirituality, personality, noble morals, intelligence, concern for society, nation, and state and the skills needed for themselves (Saringatun et

al., 2021). Thus, education plays a role in the learning process as a form of developing potential learning outcomes for students (Anwar, 2019). Education is one of the principles of civilization that display a greatly influential and crucial authority in improving the character of human beings in Indonesia in realizing national development (Rezki, 2018). Dengan demikian, bidang yang menjadi contoh pengaruh pembangunan nasional yaitu bidang pendidikan dikarenakan dipengaruhi oleh adanya sebuah perkembangan informasi dan teknologi diharapkan dapat menjadi sarana dan komunikasi dalam pembelajaran di antara guru dan siswa, salah satunya dalam pembuatan media pembelajaran (Sejati & Koeswanti, 2020).

Educational media is crucial for teachers to use, as a result, act as a liaison in delivering material so that students can quickly understand, so that it will encourage Learning a outcomes of the students themselves (Wahyuningtyas & Sulasmono, 2020). In creating efficient and effective learning activities, appropriate learning activities are required so that teachers can deliver lessons optimally to students so that they can be absorbed well (Sapriyah, 2019).

With the intention of improve superior globalization in managing human resources competence in the world of a education, an educator is needed with the ability to utilize technology and information in creating learning media (Yenti et al., 2022). This is in line with the Government Regulation of the Republic of Indonesia No. 57 of 2021 concerning facilities and infrastructure, where LKPD is included in a category of facilities. LKPD is a learning resource containing exercises and activities to foster understanding and students become easy in developing learning in the material so that the contents can be developed and designed with conditions and situations in learning activities. Media in learning that influences teachers and students in a learning process is LKPD. Student interaction with teachers can be helped effectively using LKPD. By using LKPD, students will have more opportunities to be active in an activity, so that teachers can be helped in a learning process that is carried out.

Evidence in a place indicates that teachers haven't entirely utilized media in learning implementing learning and LKPD developed by teachers has not been maximized. This is because teachers have not been able to develop an LKPD so that it does not improve students' talents and interests. In the classroom, teachers are also still rare in implementing a complete learning and re-developing the teaching materials taught. Well, teachers still tend to use Kemendikbud sources, namely student books and teacher books (Susanti et al., 2021a). To encourage students' critical thinking skills, LKPD with a STEM approach is suitable for development (Lestari et al., 2018). STEM-based LKPD can encourage creative thinking skills in students to become a learning resource and be effective in proper learning (Aldila et al., 2017).

Research on the development of LKPD has been widely conducted, such as the development of STEM (science, technology, engineering, and mathematics) based LKPD in biology learning on ecosystem material (Khairunnisa & Tanjung, 2023; Nofriands et al., 2022), virus material (Pasaribu et al., 2023; Safitri & Tanjung, 2023) human movement system material (Syahril et al., 2023). However, in this study STEM (science, technology, engineering, and mathematics) based LKPD was developed on the human digestive system material.

Learning in STEM is designed with the aim of developing competencies in dealing with problems that students will face (Riyanto et al., 2021), aims to develop 21st century skills which are an alternative in learning solutions, so that this increases the potential of students (Nofriands et al., 2022). In addition, problem solving is also presented by STEM (Curtis, 2014). To find solutions and understand concepts, students are directed to solve a problem themselves. This is a characteristic of improving skills in creative thinking (Vanesha et al., 2022a).

The STEM Learning stages consist of problem identification, understanding the problem, solution formulation, solution implementation, reviewing the solution and new problems (Babierra et al., 2022). STEM has a positive impact on student engagement and motivation regarding learning activities, namely engineering and science. The STEM approach is also effective in changing students' self-confidence and changing their attitudes during learning (Yusuf & Asrifan, 2020). The STEM approach provides an opportunity where students can learn about principles, concepts and techniques in processes, products, systems, and will apply science, technology, engineering and mathematics to everyday activities (Destiara et al., 2021).

STEM-based LKPD is a learning LKPD in the form of an interdisciplinary approach by combining science, mathematics, technology and engineering which is useful for training the level of thinking (Pusfarini et al., 2016). Biology learning, very rarely uses experimental methods in learning due to the lack of time allocation required (Arifuddin et al., 2017).

Based on the background, the author intends to conduct a study entitled "development of student worksheets (LKPD) based on STEM (science, technology, engineering, and mathematics) on the material of the human digestive system for class XI high school students". This LKPD media is used in biology learning which is useful for attracting students' interest, so that learning becomes active. This is supported by (Fauziah et al., 2022; Kurniawati & Susatyo, 2021) He showed that with the help of LKPD media, the material presented was easy to understand, the learning concepts presented were more practical compared to using only textbooks and LKS media. By using the STEM approach, students will have the potential to develop skills, namely communication, problem solving and collaboration skills (Annisa et al., 2019).

This study aims to develop STEM (science, technology, engineering, and mathematics) based LKPD learning media on the Human Digestive System Material to determine the feasibility, practicality, and effectiveness of the learning media created. This is to encourage understanding of the food digestive system material at the MA level. The output of this research is expected to produce STEM-based LKPD learning media that are feasible, practical, and effective in the teaching and learning process.

Methods

The approach applied in this research is to use the research and development method with the ADDIE model (Branch, 2009). The ADDIE model consists of five steps, namely: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation (Sugiyono, 2018). The most effective model for developing products is the ADDIE Model compared to other models. The reason is, it provides an opportunity for a revision of the product based on a validity test that is designed in a structured manner (Mariam, 2019) Validation was attended by 1 learning media expert, 1 subject matter expert and 1 field practitioner expert (biology teacher). The field test of validation and reliability of the assessment instrument was conducted at High School Students Tahfizil Qur'an Yayasan Islamic Center Sumatera Utara in June 2024 by class XI-IPA students with 35 respondents. Meanwhile, the development of ADDIE has the following stages:

Table 1. Stages of ADDIE Model Product Development

No.	Steps	Data Collection Technique	Data	Analysis
1.	Analysis (analyze)	Needs analysis in the form of a questionnaire for students and interview guidelines for teachers	Qualitative	Descriptive
2.	Design (designing)	Product Design	Qualitative	Descriptive

3.	Development (developing)	Realization of making LKPD using canva	Qualitative	Descriptive
		Validation (learning media experts, subject matter experts and field practitioner experts (biology teachers))	Quantitative	Descriptive statistics
4.	Implementation (implementing)	product feasibility test, product practicality and effectiveness test	Quantitative	Descriptive statistics
5.	Evaluation	Revision from the beginning of the creation of STEM-based LKPD to the implementation stage	Qualitative	Descriptive

This data was analyzed using quantitative and descriptive qualitative analysis methods. The quantitative method involves processing data by converting it into percentages or numerical forms. Qualitative analysis, on the other hand, derives insights from data collected in the form of words, sentences, and conclusions. The qualitative analysis technique involves categorizing information from qualitative data, which includes evaluations, suggestions for improvement, and responses gathered from interview results, expert validation, and student needs analysis questionnaire results. Quantitative data analysis in this study, namely the implementation instrument in the form of a practicality sheet, namely a student response questionnaire and an effectiveness analysis, namely the value of a pre-test and the value of a student post-test, is used to determine the effectiveness of STEM-based LKPD. The criteria for drawing conclusions used in assessing the feasibility of the media are the results of expert validation using the achievement level criteria listed in Table 2.

Table 2. Eligibility Criteria

Percentage (%)	Criteria
81-100	Very Worthy
61-80	Worthy
41-60	Quite Decent
21-40	Not Feasible
0-20	Totally Unworthy

source: (Ernawati & Sukardiyono, 2017)

A criteria for drawing conclusions applied in the assessment of the practicality of implementing changes in the level of achievement with a scale can be seen in Table 3.

Table 3. Guttman Scale Practicality Criteria

Percentage (%)	Criteria
81-100	Very Practical
61-80	Practical
41-60	Quite Practical
21-40	Not Practical
0-20	Very Impractical

source: (Riduwan, 2010)

In the effectiveness test, a product is developed through an initial test with a final test that will be given to students. To determine whether or not LKPD is effective for students in developing their learning outcomes, the N-gain value or normalized gain is used by comparing the pre-test value minus the post-test with the maximum value minus the pre-test value. To find out the results of the normalized gain, see Table 4.

Table 4. Normalized gain criteria

N-gain value	Category	Treatment criteria using LKPD
$N\text{-gain} > 0,7$	High	Effective
$0,3 \leq N\text{-gain} \leq 0,7$	Currently	Effective Enough
$N\text{-gain} < 0,3$	Low	Less Effective

source: (Yunipiyanto et al., 2020)

Results and Discussion

This research produces learning products in the form of STEM (science, technology, engineering and mathematics) based student worksheets (LKPD) for the human digestive system material in class XI-IPA at high school students which are feasible, practical, and effective to use. This LKPD includes sub-materials on food substances, the digestive process in humans and disorders of the human digestive system. Study (Syarah et al., 2021) stated that the STEM approach to the human digestive system material has been effective as a material to be taught. However, in the development of LKPD, there are still few who have conducted research.

This research and development process uses the development described by (Branch, 2009) namely the ADDIE model, which begins with the analysis stage by finding facts in the field so that researchers can determine the products to be developed. The first analysis was carried out by observation at MA. Tahfizil Qur'an Yayasan Islamic Center Sumatera Utara. The results of the observation showed that teachers had not fully used the LKPD learning media, so that it was seen from the results of the learning needs analysis in the form of questionnaires for students and interview guidelines for teachers where the learning resources used by teachers were LKS, Books, and power points containing text so that the lack of maximum understanding of learning obtained by students, then in learning the teacher delivered the material in a traditional way, namely the question and answer method, lectures and discussions. In the student analysis, it can be seen that one of the abstract and micro materials is the human digestive system in biology learning at high school students. The human digestive system is known to be a material that is considered difficult for grade XI students, this is because the concept of the material is too difficult to understand, and the material is too much while the time allocation is limited, then conducting a task analysis to determine the adjustment of the task is obtained by analyzing basic competencies, and then conducting material analysis according to the 2013 curriculum, namely the human digestive system material with KD 3.7 followed by KD 4.7, then compiling learning objectives to match the basic competencies. In addition, the researcher added the lack of learning media available for students who do not have a strong understanding of the material being taught. As a result, only some students managed to achieve learning outcomes, namely cognitive according to learning objectives. In the human digestive system material, many students still do not understand the material, this is evidenced by several students not achieving the minimum completion criteria (KKM).

The next stage is the Design stage, where researchers will design a product that can offer alternatives based on problems found in the field according to experimental procedures, instructional objectives and assignment analysis and assessments that have criteria. The development stage is the realization of making LKPD using Canva which will be adjusted to validation. (learning media experts, subject matter experts and field practitioner experts (biology teachers)). In this case, the product in question is the development of LKPD based on STEM on the human digestive system material. Meanwhile, the results of product revisions by media experts & material experts are listed in Table 5. and Table 6.

Table 5. Media validation revision results

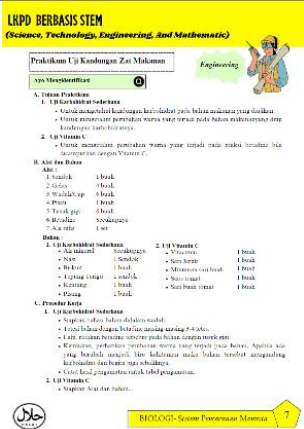
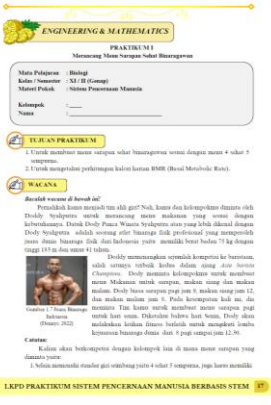
Validator Comments	Before Revision	After Revision
Reintegrate the STEM learning approach into existing materials and questions as well as experimental activities.		

Table 6. Results of the revision of the validation of the material

Validator Comments	Before Revision	After Revision
Adapting LKPD to the STEM Learning Stages, namely recognizing problems, understanding problems, formulating solutions, implementing solutions, reviewing solutions and new problems.		

These results are the result of a media review that was obtained, namely:



Figure 1.
LKPD Cover

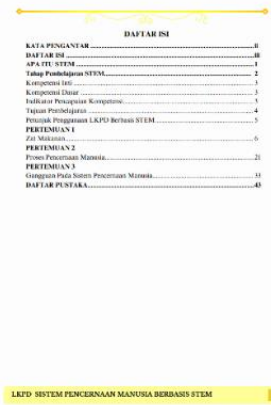


Figure 2.
List of Contents

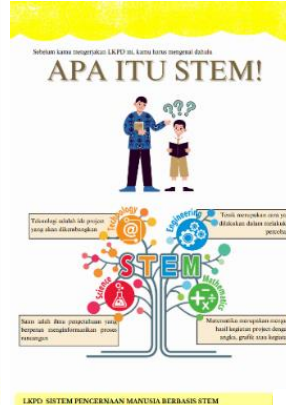


Figure 3.
Definition of STEM

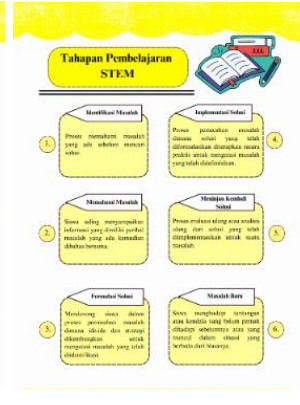


Figure 4.
STEM Learning Stages



Figure 5.
Instructions



Figure 6.
Material

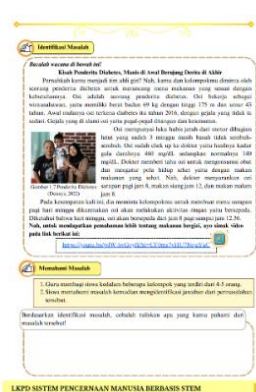


Figure 7.
Worksheet Stages

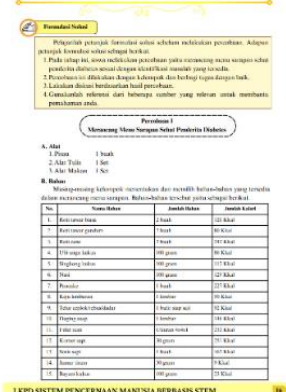


Figure 8.
STEM Worksheets

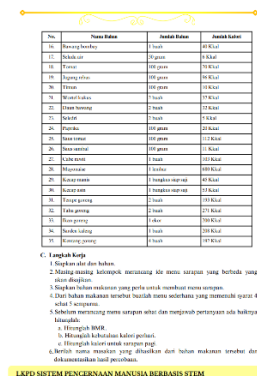


Figure 9.
Worksheet

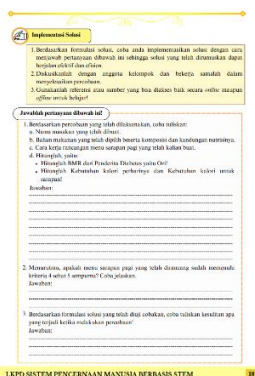


Figure 10.
Worksheet

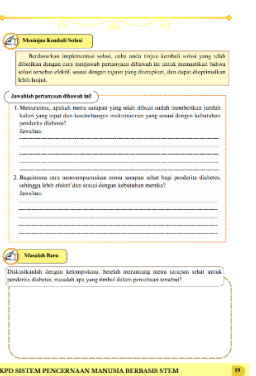


Figure 11.
Worksheet

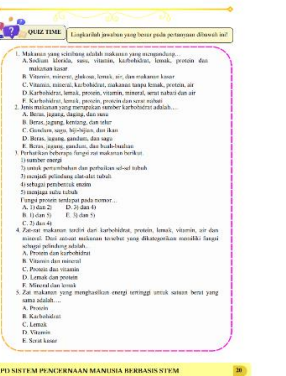


Figure 12.
Quiz

After the stage of developing STEM-based LKPD, the next stage is the Implementation stage. At this stage, STEM-based LKPD will undergo a feasibility test through a validation test, a practicality test through a student response questionnaire and an effectiveness test through a pre-test and post-test. This is to improve knowledge of a concept in the digestive system material at the High School Students level. The purpose of this process is to ensure the level of feasibility, practicality, and effectiveness in the teaching and learning process. The last stage is evaluation, which is a revision from the beginning of making STEM-based LKPD to the implementation stage so that it has a final result that is feasible, practical and effective to teach.

Media Expert Validation

STEM-based LKPD was tested for validity by the learning media validator through several aspects, namely appearance, presentation, physical criteria and media feasibility. The results of the recapitulation of media expert validation values are listed in Table 7.

Table 7. Results of the Recapitulation of Media Validation Values

No.	Aspect	Average Value	Percentage (%)	Criteria
1.	Appearance	4,6	92	Very Worthy
2.	Presentation	4,7	94	Very Worthy
3.	Physical Criteria	4	80	Worthy
4.	Media Suitability	5	100	Very Worthy

Average Percentage (%)	91,57
Criteria	Very Worthy

It is known in Table 7. the average percentage achieved is 91,57% (very worthy). The total percentage in the appearance aspect is 92% (very worthy), the physical criteria aspect is 80% (worthy), the presentation aspect is 94% (very worthy) and the media feasibility aspect is 100% (very worthy). The maximum criteria in LKPD, especially in STEM learning materials and stages, need to be created in an interesting and structured way. Based on (Susanti et al., 2021b) student-focused learning is becoming a trend in the world of education, especially in learning. LKPD media plays an important role in supporting learning that is conveyed to students because it guides student learning activities.

Subject Matter Expert Validation

STEM-based LKPD is tested for validity by the subject matter validator through several aspects, namely material feasibility, material accuracy, up-to-dateness and contextuality, material authenticity, material suitability with experiments and evaluations and language. The results of the recapitulation of the validation values of the material experts are listed in Table 8.

Table 8. Recapitulation Results of Material Validation Values

No.	Aspect	Average Value	Percentage (%)	Criteria
1.	Material Feasibility	5	100	Very Worthy
2.	Material Accuracy	5	100	Very Worthy
3.	Criteria For Up To Dateness And Contextuality	4,6	92	Very Worthy
4.	Originality Of The Material	5	100	Very Worthy
5.	Experiment And Evaluation	5	100	Very Worthy
6.	Language	5	100	Very Worthy
Average Percentage (%)			98,6	
Criteria				Very Worthy

It is known in Table 8. the average percentage achieved is 98,6% (very worthy). The total percentage of the material feasibility aspect is 100% (very worthy), the material accuracy aspect is 100% (very worthy), the aspect of the criteria for up to dateness and contextuality is 92% (very worthy), the aspect of the originality of the material is 100% (very worthy), the aspect of the suitability of the material with the experiment and evaluation is 100% (very worthy) and the language aspect is 100% (very worthy). According to the expert validation lecturer of the material, STEM-based LKPD when viewed based on the learning aspect, the presentation of the material is in accordance with core competencies, basic competition, learning objectives, the material is easy for students to understand and in accordance with the STEM learning stage. Based on (Suwastini et al., 2022) said LKPD plays a role as a direction of learning for students and makes it easier for students and teachers to carry out learning and teaching activities. The use of LKPD has proven effective in exploring knowledge, learning outcomes, skills and attitudes of students. LKPD also supports understanding of materials and conducting experiments, outside and inside the classroom and at home. LKPD based on cooperative learning encourages students' curiosity, motivation, and collaboration, and functions as a stimulus in the learning process, as long as it is prepared by considering the material being taught and the needs of students.

Validation of Field Practitioner Expert (Biology Teacher)

STEM-based LKPD was tested for validity by expert validators in the field (biology teachers) through several aspects, namely language, content/material, presentation and overall function of STEM-based LKPD. The results of the recapitulation of the validation values of expert field practitioners (biology teachers) are listed in Table 9.

Table 9. Results of the Recapitulation of the Validation Values of Expert Field Practitioners (Biology Teachers)

No.	Aspect	Average Value	Percentage (%)	Criteria
1.	Content/Material	4,2	86	Very Worthy
2.	Language	4	80	Worthy
3.	Presentation	4,2	84	Very Worthy
4.	Overall Function	4,5	90	Very Worthy
Aspect Of STEM-Based LKPD				
Average Percentage (%)			85	
Criteria			Very Worthy	

It is known in Table 9. the average percentage achieved is 85% (very worthy). The total percentage in the content/material aspect is 86% (very worthy), the language aspect is 80% (worthy), the presentation criteria aspect is 84% (very worthy) and the overall function aspect of STEM-based LKPD is 90% (very worthy). Based on (Geni et al., 2020) revealing appropriate teaching media can directly have a positive impact and provide interest in its use.

After the validation stage and a few improvements based on input from expert media validators, material experts, and field practitioner experts (biology teachers). Furthermore, STEM-based LKPD was tested using a questionnaire sheet, namely the responses of the students themselves which were calculated using the Guttman scale. Meanwhile, the way to find out the practicality of a media that is taught is by collecting responses to students' understanding of the material and the appeal of the learning media. The student response data is class XI-IPA totaling 35 people with a questionnaire answered, namely 14 statements. The validation value of the student response questionnaire is listed in Table 10.

Table 10. Recapitulation Results of Student Response Questionnaires

No.	Aspect	Average Value	Percentage (%)	Criteria
1.	Content/Material	28	80	Practical
2.	Language	29	82,90	Very Practical
3.	Presentation	27,4	78,42	Practical
4.	Learning Method	31	88,60	Very Practical
5.	Biology Experiment	29	82,90	Very Practical
Average Percentage (%)			82,56	
Criteria			Very Practical	

It is known in Table 10. the average percentage obtained is 82,56% (very practical). The total percentage in the content/material aspect is 80% (practical), the language aspect is 82,90% (very practical), the presentation criteria aspect is 78,42% (practical), the learning method aspect is 88,60% (very practical) and the biology experiment aspect is 82,90% (very practical).

Product Effectiveness Test

The results of the recapitulation of the product effectiveness test, the average Pre-test score was 29,107 and the average Post-test score was 87,3. The N-gain Score was 0,82 with an N-gain value > 0,7 in the high category and the treatment criteria using LKPD were effective. According to (Vanesha et al., 2022), effective learning can generally be identified and measured by how many students achieve the learning objectives. This level of

achievement also reflects the extent to which the internal learning experience can be accepted by students.

This STEM-based LKPD has advantages including improving the quality of learning so that students are ready to face future challenges. Where, STEM-based LKPD integrates concepts from various interrelated disciplines and is applied in real life and focuses on developing critical and creative problem-solving skills. STEM-based LKPD also allows students to design, create and test their own solutions to the problems given. This can provide experience, help students and improve learning to develop in facing future challenges (Aldila et al., 2017; Destiara et al., 2021; Riyanto et al., 2021; Sartika, 2019). LKPD LKPD also presents teacher interaction with students Sehingga siswa dapat terlibat dalam kegiatan pembelajaran secara mandiri, menyelesaikan latihan dan menerapkan tujuan pembelajaran. About the findings of a previous study also stated namely, this LKPD will guide a student to come up with new concepts that will be studied (Ariningtias, 2017; Pangesti et al., 2017) Using LKPD in learning activities will be able to activate students.

Conclusion

LKPD based on STEM on the material of the human digestive system for class XI high school students, the feasibility of the media is known as measured through the results of the media expert validation assessment, namely 91,57% (very worthy), material experts, namely 98,6% (very worthy) and field practitioner experts (biology teachers) namely 85% (very worthy). Then, the practicality of the media is measured using a student response questionnaire, namely 82,56% (very practical). Meanwhile, the product effectiveness test has an N-gain score of 0,82 with an N-gain value > 0,7 in the high category and the treatment criteria using LKPD are effective.

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