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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

Avina Yustriani, Zulfiani*

Biology Education Study Program, Faculty of Tarbiya and Teacher's Training, UIN Syarif Hidayatullah Jakarta, Ir. H. Juanda Street's No. 95 Ciputat 15412, Jakarta, Indonesia

*Email: zulfiani@uinjkt.ac.id

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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).

$$P = \frac{\text{The total score of the overall data collection results}}{\text{Total criterion scores}} \times 100\% \qquad (1)$$

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:

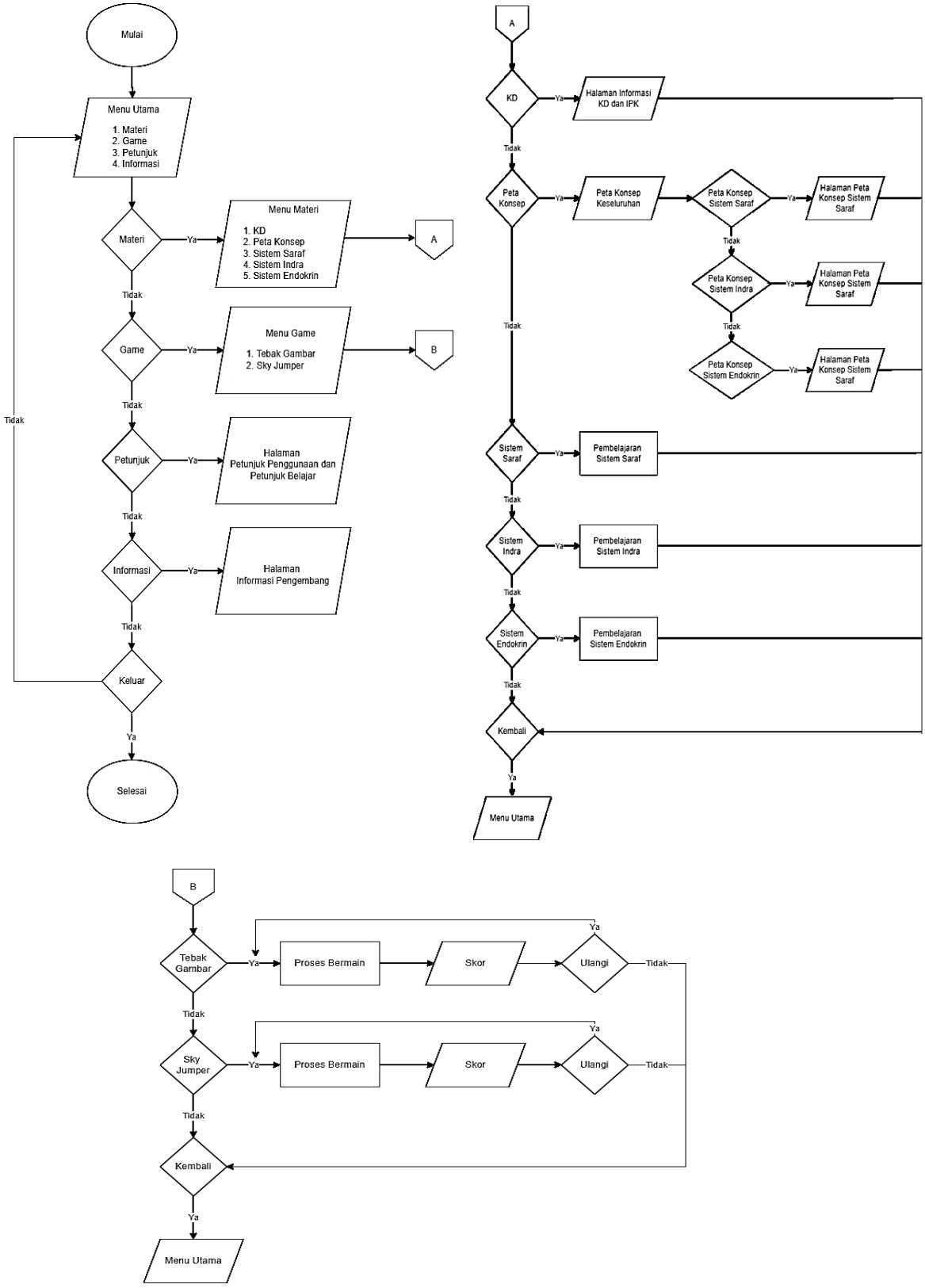
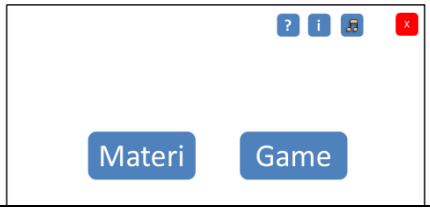
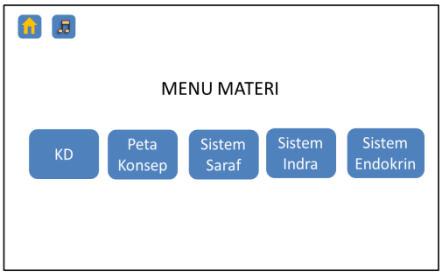
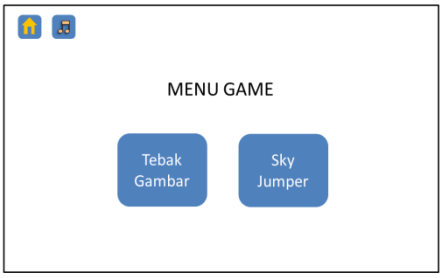


Figure 1. Flowchart Media Educational Game Coordination System

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:

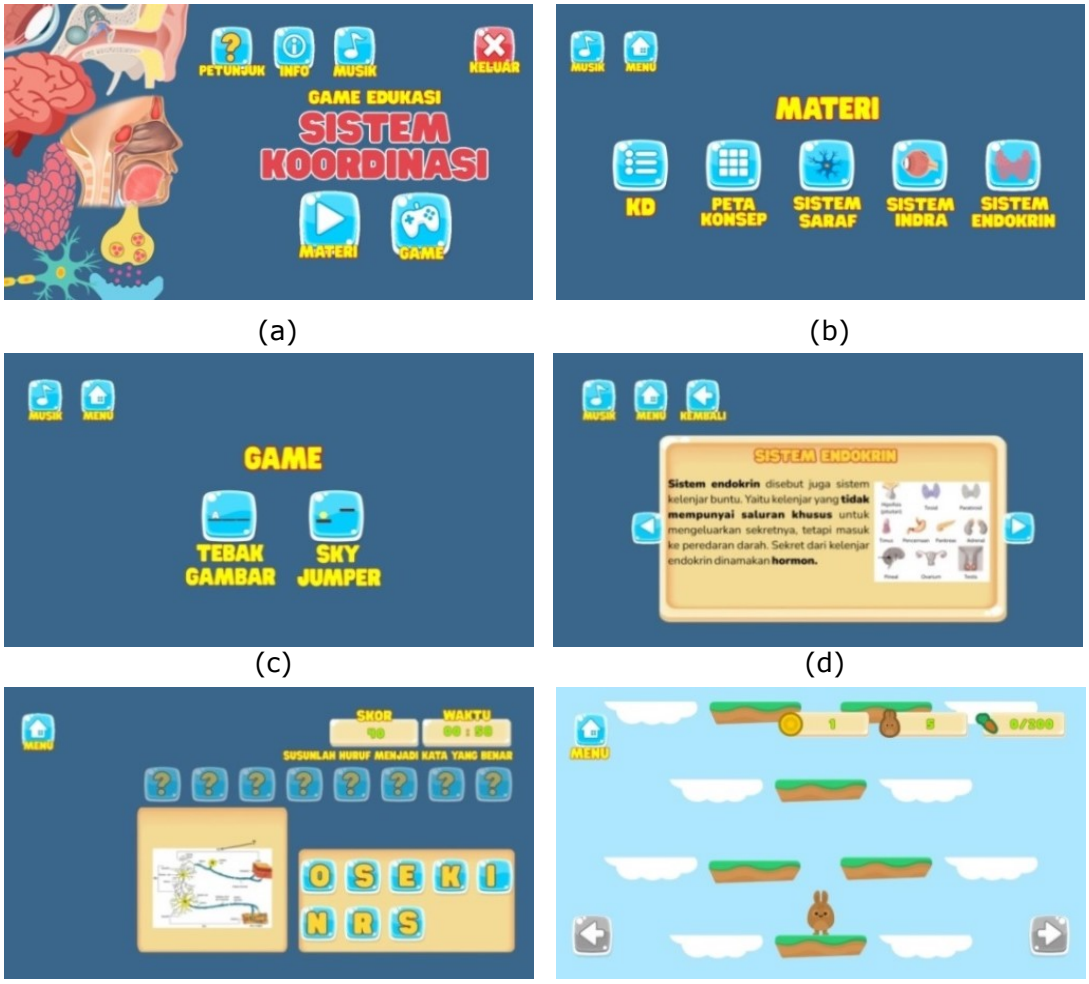


Figure 2. Results of the Coordination System Educational Game Prototype. (a) main menu, (b) material menu, (c) game menu, (d) material content, (e) *Tebak Gambar* game, (f) Sky Jumper game

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