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Developing Guided Discovery Learning-Based Neurodroid Learning Media for Critical Thinking Skills

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Abstract: This study aimed to develop guided discovery learning-based android learning media to improve critical thinking skills. The developed biology learning media was applied to the nervous system material. The discussion of the physiology of the nervous system is one of the difficult biological materials to understand because it includes the organization and structure of neurons and their functions, ion pump mechanisms when neurons are at rest, action potential mechanisms, mechanisms for neurons to communicate with other cells in the synapses, and organization of the nervous system. This study used research and development (R&D) with a method developed by Thiagarajan, namely the 4D model with stages: define, design, develop and disseminate. The stages of this study are limited to the development stage. The results showed that the media was feasible with media, language, and a material expert validation of 3.5, 3.8, and 3.3, respectively.

INTRODUCTION

The student's difficulties in learning biology have been studied by various researchers worldwide. Some topics in biology that are considered difficult for students to study are water transportation in plants, protein synthesis, photosynthesis and respiration, gas exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormone regulation, oxygen transport, genetics, Mendel, genetic engineering, and the central nervous system (Çimer, 2012; Tekkaya et al., 2001).

Biological sciences such as the nervous system include detailed and abstract concepts of biological organization level (Çimer, 2012; Tekkaya et al., 2001); plus an overloaded biology learning curriculum, interdisciplinary biology concepts, and the limitations of textbooks in presenting and explaining biological concepts Zeidan (2010); Osborne & Collins (2001). The nature of biological science, biology learning is generally based on rote learning, which includes many concepts, events, topics, and abstract facts, making it difficult for students to learn them (Bulent, 2015; Durmaz, 2016). No less important factors are the teacher's teaching style, biology teaching methods, and the use of learning media (Çimer, 2004; Etobro & Fabinu, 2017).

The actualization of biological sciences in life is needed to respond to the changes and new challenges in the 21st-century (Zabit, 2010). This shows that in biology learning, it is not only the ability to memorize concepts, events, and facts of biology, but students need critical thinking skills to answer the challenges of the 21st century. This is following Makaramani (2015) explanation that in

21st century learning that the learning process is not only contained subject matter, but every student needs to know how to use their knowledge and skills by thinking critically, applying knowledge to new situations, analyzing information, understanding new ideas, communicating, collaborating, solving problems, and making decisions.

Students' critical thinking skills can help overcome problems or challenges by considering various perspectives, understanding and organizing important facts of situations, and designing appropriate solutions (Facione, 2000). Critical thinking is a detailed description that includes the process of interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 2015). Critical thinking is also defined as an attitude of wanting to think deeply about problems and things that are within reach of one's experience, knowledge of methods, and logical reasoning and skills to apply these methods (Glaser in Fisher, 2003). The critical thinking skills possessed by students can facilitate the completion of the implementation of tasks and the process, help make their conclusions, and actualize knowledge in life (Zabit, 2010). Critical thinkers in learning activities use reflective decision-making and problem solving to analyze situations, evaluate arguments, and draw appropriate conclusions on the concept of learning material (Shehab & Nussbaum, 2015).

Through a pattern of activity, independence, and student curiosity in learning with teacher guidance, Guided Discovery Learning (GDL) is more effective than conventional models because it increases students cognitive understanding integrally (Khasanah et al., 2018; Yuliana et al., 2017). Compared to pure discovery learning with guided discovery, learning is more meaningful (Alfieri et al., 2011; Mayer, 2004). Guided discovery learning refers to the pattern of scientific methods so that students can find problem-solving by students in groups with the steps of stimulating, formulating problems/identification, collecting various data sources, performing data processing, confirming or re-check data sources, and the final stage is drawing conclusions (Akinbobola & Ado, 2007; Deswita et al., 2018; Novita et al., 2016). The benefits of GDL are to positively impact students, such as critical thinking, creativity, making decisions problem solving and motivated in learning through active (Akinyemi Olufunminiyi Akinbobola & Afolabi, 2010; Omwirhiren, 2002).

Media use in 21st-century learning is closely related to information technology as supporting material for educators in developing learning media and refers to students' critical thinking (Hidayat et al., 2019; Puspitasari et al., 2018). Technological development is one alternative for effective, efficient, and superior learning media. Therefore, android-based learning is effectively used as a learning medium in the 21st century (Yusuf, Widyaningsih, & Purwati, 2015).

Utilizing technology in instructional media greatly helps improve problem-solving abilities and learning outcomes (Astutia et al., 2017). One use of technology in learning is learning with cellular. The use of cellular as a learning medium has a better and more effective impact and can enrich experiences in the learning process of students (Fulantelli et al., 2014; García-Peñalvo & Conde, 2015) (Adnan & Prasetyo, 2017. Mobile learning provides various application programs that students can access, for example, Android programs (Abildinovaa et al., 2016).

Android can be the right learning media, especially for high school students, because almost every student sees it as an object of activity and interaction with a duration that is often used (Mardiana & Kuswanto, 2017). Android can also help students access information at any time as needed (Ligi &

Raja, 2017). Tania & Jumadi (2020) also adds that androids can enhance learning in various ways and contexts. Potential and existing problems, this research focuses on the development of learning media based on a combination of the android nervous system and guided discovery learning on its effect on critical thinking skills.

METHOD

This research and development study aims to develop learning media for android-based nervous system material (Neurodroid). This study uses research and development (R&D) with the method developed by Thiagarajan et al., (1974) of 4D model stages (define, design, develop, and disseminate).

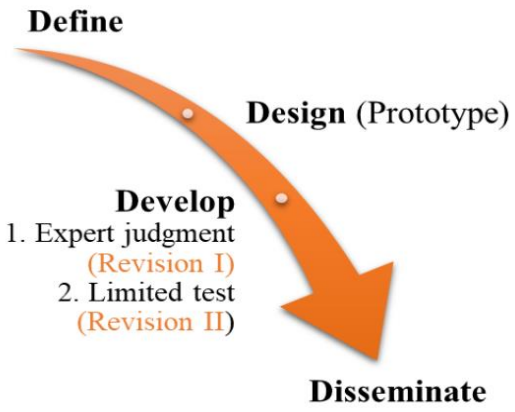

Figure 1. 4D Model

The initial step in this research model starts from the define stage, which is to determine the needs needed by students in studying the nervous system. At this stage, several things must be analyzed, starting from analyzing student needs, concept analysis, task analysis, and formulation of learning objectives. All that is done in the first stage is to define aims to provide an overview and determine the type of media to be created.

The second step is designing, starting from making a storyboard, describing the concept of the material and determining the images and videos that will be included in the Neurodroid media, and compiling instruments to measure students' critical thinking skills that are separate from Neurodroid media but are an integral part of the research. Neurodroid media is made using the android studio 3.6.3 application.

Next is the development stage, which is developing respiradroid media, to produce development products at this stage, carried out through two steps, namely: (1) expert assessment in the field, followed by revisions, (2) developmental testing (developmental testing) the goal is to retrieve data for media validation from students. Two material experts and two media experts conduct product viability testing. Data analysis uses a mean score which is then converted to a standard value in the form of a percentage of feasibility. The final stage is dissemination. The media that have been developed will then be used by other students and disseminated.

The sample of this study was students of class XI MIA of SMAN 48 Jakarta, with 76 students. The research design carried out in this study was using Quasi-Experimental Design. This can control all external variables that affect the course of the experiment.

Table 1. Research Design

Class	Pretest	Treatment	Postest
E (R)	O_1	X_1	O_2
C (K)	O_3	X_2	O_4

Note:
E= Experiment class
C = Control Class
R = The sample of each class was determined randomly
O_1= The pretest results of the experimental class
O_2= The results of the experimental class post-test
O_3= Control class pretest results
O_4= The results of the control class post-test
X = Treatment

Test the validity of the study using the Point Biserial correlation formula using the following formula:

$$Rpbi = \frac{Mp-Mt}{Sdt}\sqrt{\frac{p}{q}}$$ (Arikunto, 2012)

RESULT AND DISCUSSION

The descriptive analysis and hypothesis testing showed that guided discovery learning-based Neurodroid media had a significant effect on students' critical thinking skills. Students taught using guided discovery learning-based Neurodroid media were higher than students taught using conventional learning.

The reactions obtained from this stage are from assessment results from judgment experts, namely media and material experts. The validation results ensure good qualifications based on the assessment given by experts with an average value of 3.5, meaning that the Neurodroid media developed is valid (Table 2).

Table 2. Product Expert Validation Results

No	Aspect	Indicator	Validator Value 1	Validator Value 2	Average	Information
1	Quality Appearance	Presentation of the initial display of Android-based learning media that makes it easier to determine the next activity	4	4	4	Valid
		Icons/buttons make it easier for users to use Neurodroid media	4	3	3.5	Valid
		The firmness of the hierarchy in the material menu in the Neurondroid media	4	3	3.5	Valid
		Page layouts and layouts	4	3	3.5	Valid
		The suitability of using text color and typeface on android-based learning media	3	3	3	Valid
		The suitability of the proportions of the images presented with the display of android-based learning media	3	4	3.5	Valid
		The process of loading on android-based learning media	4	3	3.5	Valid
2	Manipulation Software	Ease of searching for content (syllabus, concept maps, materials, and learning evaluation)	4	4	4	Valid
		Ease of finding content (syllabus, concept maps, learning materials, and evaluations)	3	3	3	Valid
Total				**3.5**		

The next assessment criteria (Table 3.), namely aspects of implementation and interface, contain items presenting Neurodroid media's implementation, appearance, display design, and image format and media resolution of Neurodroid media. Based on the validation results from the experts, they stated that the implementation and interface aspects were valid with a result of 3.08, which means that the Neurodroid media was valid. The suitability of the format and resolution is displayed by considering the choice of colors and a soft display to not interfere with students' vision and comfort when learning.

Table 3. Product Expert Validation Results

No	Aspect	Indicator	Validator Value 1	Validator Value 2	Average	Information
3	Execution	The presentation of Android-based learning media allows users to learn independently	3	3	3	Valid
		Android-based learning media can be used anytime and anywhere by users	4	3	3.5	Valid
4	*Interface*	The interface display on Android-based learning media has a good layout	3	3	3	Valid
		Learning media display design Android-based According to the user level	3	3	3	Valid
		Color selection accuracy, color balance, typeface, and the font size on Android-based learning media	3	3	3	Valid
		The suitability of the format and resolution of the images presented with the display on Android-based learning media	3	3	3	Valid
Total				**3.08**		**Valid**

Media experts provide product validation results on reusable, maintenance, and compatibility criteria confirming good qualifications with an average value of 3.3, meaning that the developed Neurodroid media is already valid (Table 4.). So that the average results of validation by media expert validation are 3.29, it shows that it is valid.

In Table 5, it can be explained that before applying guided discovery learning-based Neurodroid media, the average achievement of students in critical thinking skills was 51.48 in the experimental class and 51.84 in the control class. These results indicate that none of the students achieved the KKM score of 75, both in the experimental and control classes.

Table 4. Product Expert Validation Results

No	Aspect	Indicator	Validator Value 1	Validator Value 2	Average	Information
5	*Reusable*	Almost all learning programs on Android-based learning media can be reused to develop other teaching materials	4	3	3.5	Valid
6	*Maintainable*	Android-based learning media is easy to install or uninstall from smartphones	4	3	3.5	Valid
		Android-based learning media master files are easy to transfer from one smartphone to another	3	3	3	Valid
7	*Compatibility*	Android-based learning media applications can be run on the majority of Android versions currently used	3	3	3	Valid
		Android-based learning media can run on all screen resolutions	3	4	3.5	Valid
Total				**3.3**		**Valid**

Table 5. Descriptive Statistics of Critical Thinking Skills

Indicator	Average	
	Neurodroid	
	Pretest	Posttest
Mean	55.00	87.04
Min	40.00	72.50
Max	72.50	95.00
Standard Deviation	7.68	5.25

Table 6. Average Critical Thinking Skills per Indicator (n = 76)

Indicator	Average Critical Thinking Skills	
	Neurodroid	
	Pretest	Posttest
Interpretation	76,32	96.38
Analysis	67.93	94.90
Conclusion	56.58	88.65
Evaluation	50.66	79.93
Explanation	41.94	77.30
Self-regulation	45.07	86.18

Based on Table 6, the highest score in the experimental class is on the interpretation indicator, namely 96.38, while the lowest value is in the explanation indicator, which is 77.30. After learning with guided discovery learning-based Neurodroid media, students can interpret, analyze, conclude, evaluate, explain the nervous system material both on the aspects of the nerve cell parts and their functions, the principle of impulse delivery, the mechanism of movement, and reflex motion, the nervous system structure and disorders of the nervous system.

However, if viewed from the increase in the value of the pretest to the post-test, the self-regulation indicator was the indicator that experienced the largest increase, with a difference of 41.11, which initially scored 45.07 to 86.18. At the same time, the indicator with the lowest increase is the interpretation indicator with a difference of 20.06, which initially scored 76.32 to 96.38. These data indicate that guided discovery learning-based Neurodroid media can improve critical thinking skills. This is in line with Aprelianda & Yerimadesi (2019); Arya Wulandari et al., (2018); Noviyanti et al., (2019); Perwitasari & Djukri (2018)) stated that the guided discovery learning model has a significant effect and can improve the critical biological thinking of high school students.

The guided discovery model is deliberately designed to increase students' activeness, is process-oriented, and students can find and have their information needed to achieve learning goals (Yuliani, 2015). Learning activities like this make students active in the learning process. The teacher only acts as a facilitator to organize the course of learning. The learning process has a positive impact on the development of students' critical thinking, helps students develop intellectual discipline, the need for skills arouses curiosity, and seeks answers to curiosity. In addition, guided discovery learning can encourage students to think for themselves and analyze themselves to find general principles based on the material or data provided by the teacher. Students are trained to build thinking skills that focus on understanding in the guided discovery model. This is similarly expressed by Risdianto et al., (2013). The purpose of guided discovery learning is to provide a way for students to develop intellectual abilities (thinking skills) related to reflective thinking processes.

The results of this study indicate that the guided discovery learning model

is more suitable with the characteristics of high school students because to support the application of the guided discovery model in the learning process, the teacher as a facilitator needs to provide learning media, such as modules to help students learn both independently and in groups. This statement is supported by Udo (2010), and Akinbobola & Afolabi (2010) that guided discovery is most effective for student-centered learning and facilitates student learning outcomes. This is because what is meant by the discovery in guided discovery is not finding something completely new. Still, in this model, students are expected to actively find knowledge such as guessing, estimating, and trying to find concepts, formulas, and the like. Students find the concept through guidance and direction from the teacher because, in general, most students still need basic concepts to find something.

Guided discovery is very useful for learning the nervous system using media following abstract biological characteristics. This aligns with Sugiyono (2017), arguing that guided discovery is learning using discovery. Students gain knowledge to be understood with teacher guidance, such as through questions, demonstrations, or other media. Likewise, according to Markaban (2006), the guided discovery syntax is (1) the teacher formulates problems that will be given to students with data according to the topic of discussion; (2) students look for, process, compile, and analyze data; (3) students make conjectures (predictions) from the results of the analysis carried out; (4) then the hypothesis made by the students is examined by the teacher; (5) verbal presentation or presentation is also carried out by students to be discussed, processed and confirmed together; (6) After students find what they need, the teacher provides additional exercises or questions to check whether the findings are correct. From the description above, it can be concluded that guided discovery is a learning model that presents a problem or question that allows students to think, observe, make guesses, explain, and analyze to find guidance and instruction from the teacher.

In the control class with the application of conventional learning, critical thinking skills were lower (Table 3) than the experimental class that applied guided discovery with Neurodroid media. The value of students has increased, but it is still low in some aspects. Such as the analysis and explanation aspects, which only score 71% each. This is because the discussion process has not been optimal and has not generated curious problems to be solved. It has not been able to properly analyze and evaluate neuron system material. This is also due to the absence of a component to formulate problems and determine hypotheses in the student worksheet. Learning focuses on the discussion between groups that are not directed so that students are less motivated in critical thinking. This can be seen during the presentation. Some group members who appeared chose to be silent and relied more on the group leader to present and answer questions from other group members.

In the control class, facilitators' teachers do not contribute less to the learning process. The teacher only provides direction at the beginning and the initial activities. This causes students to take important points from the book to be presented. Group members also did not understand what they were presenting. Several groups were still wrong in compiling the concepts presented. This is not right because wrong concepts have been formed in students' memory before any improvement or validation from the teacher.

The group that appeared was also unable to answer the other groups' questions. This shows that the management of the discussion is not good, especially at the planning stage, which causes the implementation stage not to go well, which impacts the

achievement of learning targets. According to Gupta & Ahuja (2014) and Espey et al. (2017), teachers as facilitators must encourage students to initiate discussions and ask questions for clarification. Furthermore, Jarmita (2012) added that in group discussions, teachers must also assist in finding answers with the flow of thought of each student.

The calculation of critical thinking skills results shows normal and homogeneous data. The correlation test shows that the pretest is significantly correlated with the post-test, so the ANOVA test is needed to determine whether the pretest affects the post-test. Without the pretest value, there is an effect of using guided discovery and conventional Neurodroid media on the post-test scores of critical thinking skills, which means that the post-test scores obtained by students are correct because of the influence of the learning model applied, not because of the experience of students or because they have studied system material nerves before.

Figure 2. Product Guided Discovery-Based Neurodroid Learning Media of Critical Thinking Skills

Guided Discovery Learning syntax consists of providing a stimulus, identifying problems, collecting data, processing data, and drawing conclusions integrated on Neurodroid media. The stimulus and problem finding stages can train critical thinking skills in interpretation. The teacher conducts question and answer sessions and guides students to formulate problems related to the problem. Furthermore, students are guided to formulate hypotheses relevant to problem identification. Each group conveys ideas to formulate hypotheses based on problem identification from the findings on the stimulus by following the teacher's guidelines in determining priorities in the investigation. Formulating a hypothesis can train critical thinking skills in aspects of analysis and concluding (Harahap, 2020). The process of student discussion in analyzing the reasons is carried out by each member before setting a hypothesis. After considering opinions and determining ideas from group members, students collected information from the Neurodroid media and presented material supported by pictures and videos to strengthen the hypothesis. Stage, to solve problems able to train students' critical thinking skills in analysis and explanation (Harahap, 2020).

Group members collect information and evidence from various literature to answer the problem. Furthermore, students can find and develop the concept of knowledge and end up at the analysis, discovery, and concluding stage. In line with Erikson & Erikson (2018), presentations are an effective and useful way to improve student's communication

skills, increasing their critical thinking skills. The teacher and students discuss the results of each group in the form of validation or correction, confirmation and ending with withdrawal from the discussion process. Drawing conclusions can train students' critical thinking skills on withdrawal and self-regulation. Students who think critically will have confidence and offer responses to the conclusions made (Harahap, 2020).

CONCLUSION

The research and development that has been done show that guided discovery-based Neurodroid media significantly affects students' critical thinking skills. Students taught using guided discovery learning-based Neurodroid media increased 41.11 %. The developed media is expected to assist teachers in directing students to think critically because the media provides a stimulus at the beginning of learning in the form of pictures and then explains the material accompanied by pictures and videos in a complex and detailed manner. Likewise, the Neurodroid media is equipped with multiple choice practice questions to verify students' understanding. So that, when there is an incorrect answer, students want to review the material on the nervous system. The end of the media is closed in the form of conclusions from learning material on the nervous system. Integrated discovery learning with supported images and videos can hone students' critical thinking.

REFERENCES

Abildinovaa, G. M., Alzhanova, A. K., Ospanovab, N. N., Taybaldievac, Z., Baigojanovaa, D. S., & Pashovkina, N. O. (2016). Developing a mobile application "educational process remote management system" on the android operating system. *International Journal of Environmental and Science Education*, *11*(12), 5128–5145.

Akinbobola, A.O., & Ado, I. B. (2007). Hands-on and minds-on strategies for teaching of force: Guided discovery approach. In *Proceeding of the Science Teachers Association of Nigeria (STAN) primary science workshop.* Printing & Publishing.

Akinbobola, Akinyemi Olufunminiyi, & Afolabi, F. (2010). Analysis of science process skills in West African senior secondary school certificate physics practical examinations in Nigeria. *American-Eurasian Journal of Scientific Research*, *4*(5), 234–240.

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology*, *103*(1), 1–18.

Aprelianda, N., & Yerimadesi, Y. (2019). Pengembangan modul stoikiometri berbasis guided discovery learning untuk kelas X SMA/MA. *Ranah Research: Journal of Multidisciplinary Research and Development*, *1*(4), 1129–1138.

Arikunto, S. (2012). *Pengembangan instrumen penelitian dan penilaian program*. Rineka Cipta.

Arya Wulandari, I. G. A. P., Sa'Dijah, C., As'Ari, A. R., & Rahardjo, S. (2018). Modified guided discovery model: a conceptual framework for designing learning model using guided discovery to promote student's analytical thinking skills. *Journal of Physics: Conference Series*, *1028*(1). https://doi.org/10.1088/1742-6596/1028/1/012153

Astutia, I. A. D., Sumarni, R. A., & Saraswati, D. L. (2017). Pengembangan media pembelajaran fisika mobile learning berbasis android. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *7*(2), 160–167. https://doi.org/10.21009/jrpk.072.10

Bulent, A. (2015). The investigation of science process skills of science teachers in terms of some variables. *Educational Research and Reviews*, *10*(5), 582–594. https://doi.org/10.5897/err2015.2097

Çimer, A. (2004). *A study of Turkish biology teachers' and students' views of effective teaching in schools and teacher education*. The University Of Nottingham.

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews*, *7*(3), 61–71. https://doi.org/10.5897/ERR11.205

Deswita, L., Fauzan, A., & Yerizon. (2018). Increased activity , ability to understand concepts and mathematical problem solving through guided discovery learning models of class VII 2 of SMP Negeri 15 Sijunjung Academic Year 2017/2018. *International Journal of Progressive Sciences and Technologies (IJPSAT) ISSN: 2509-0119.*, *11*(2), 101–107.

Durmaz, H. (2016). The effect of an instructional intervention on enhancement pre-service science teachers' science processes skills. *Asia-Pacific Forum on Science Learning and Teaching*, *17*(2), 1–29.

Espey, E., Baty, G., Rask, J., Chungtuyco, M., Pereda, B., & Leeman, L. (2017). Emergency in the clinic: a simulation curriculum to improve outpatient safety. *American Journal of Obstetrics and Gynecology*, *217*(6), 699.e1-699.e13. https://doi.org/10.1016/j.ajog.2017.09.008

Etobro, A. B., & Fabinu, O. E. (2017). Students' perceptions of difficult concepts in Biology in senior secondary schools in Lagos State. *Global Journal of Educational Research*, *16*(2), 139. https://doi.org/10.4314/gjedr.v16i2.8

Facione, P. A. (2015). Critical thinking: What it is and why it counts. In *e-conversion - Proposal for a Cluster of Excellence: Vol. XXVIII* (Issue 1).

Fulantelli, G., Taibi, D., & Arrigo, M. (2014). A framework to support educational decision making in mobile learning. *Computers in Human Behavior*, *47*, 50–59. https://doi.org/10.1016/j.chb.2014.05.045

García-Peñalvo, F. J., & Conde, M. (2015). The impact of a mobile personal learning environment in different educational contexts. *Universal Access in the Information Society*, *14*(3), 375–387. https://doi.org/10.1007/s10209-014-0366-z

Gupta, M., & Ahuja, J. (2014). Cooperative integrated reading composition (CIRC): Impact on reading comprehension achievement in English among seventh graders. *International Journal of Research in Humanities, Arts and Literature*, *2*(5), 37–46.

Hidayat, Z., Ratnawulan, & Gusnedi. (2019). Analysis of learning media in developing science textbooks with theme energy in life using integrated model for integrated 21st century learning. *Journal of Physics: Conference Series*, *1185*(1). https://doi.org/10.1088/1742-6596/1185/1/012070

Jarmita, N. (2012). Penerapan pembelajaran kooperatif tipe STAD dalam meningkatkan pemahaman matematis siswa pada pokok bahasan bangun ruang. *Jurnal Ilmiah Didaktika*, *13*(1), 150–172. https://doi.org/10.22373/jid.v13i1.470

Khasanah, V. N., Usodo, B., & Subanti, S. (2018). Guided discovery learning in geometry learning. *Journal of Physics: Conference Series*, *983*(1). https://doi.org/10.1088/1742-6596/983/1/012160

Ligi, B., & Raja, B. W. D. (2017). Mobile

learning in higher education. *Proceedings of the 16th International Conference Mobile Learning 2020, ML 2020*, *5*(4), 97–101. https://doi.org/10.29121/granthaalayah.v5.i4(se).2017.1942

Makaramani, R. (2015). 21st century learning design for a telecollaboration project. *Procedia - Social and Behavioral Sciences*, *191*, 622–627. https://doi.org/10.1016/j.sbspro.2015.04.567

Mardiana, N., & Kuswanto, H. (2017). Android-assisted physics mobile learning to improve senior high school students' divergent thinking skills and physics HOTS. *AIP Conference Proceedings*, *1868*. https://doi.org/10.1063/1.4995181

Markaban. (2006). *Model pembelajaran matematika dengan pendekatan penemuan terbimbing*. Depdiknas.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist*, *59*(1), 14–19.

Novita, S., Santosa, S., & Rinanto, Y. (2016). The comparison of student analitycal thinking between the implementation of cooperative learning and guided discovery learning model. *Proceeding Biology Education Conference*, *13*(1), 359–367.

Noviyanti, E., Rusdi, R., & Ristanto, R. H. (2019). Guided discovery learning based on internet and self concept: enhancing student's critical thinking in biologi. *Indonesian Journal of Biology Education*, *2*(1), 7–14. https://doi.org/10.31002/ijobe.v2i1.1196

Omwirhiren, E. (2002). The effect of guided discovery and traditional methods on the achievement of SSCE students in the chemical energetics. *African Journal of Research in Education*, *2*(2), 21–24.

Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: A focus-group study. *International Journal of Science Education*, *23*(5), 441–467. https://doi.org/10.1080/09500690010006518

Perwitasari, N., & Djukri, D. (2018). Developing thematic-integrated module based on guided discovery to improve critical thinking and student science attitude. *Jurnal Prima Edukasia*, *6*(1), 44–55. https://doi.org/10.21831/jpe.v6i1.15218

Puspitasari, E. D. T., Surjono, H. D., & Minghat, A. D. (2018). Utilizing web based learning as 21st century learning media for vocational education. *International Journal of Engineering and Technology(UAE)*, *7*(4), 157–160. https://doi.org/10.14419/ijet.v7i4.33.23522

Risdianto, H., Karnasih, I., & Siregar, H. (2013). The diffrence of enhancement mathematical problem solving ability and self-efficiency SMA with MA students IPS program through guided inquiry learning model assisted autograph software in Langsa. *Jurnal Paradigma*, *6*(1), 89.

Shehab, H. M., & Nussbaum, E. M. (2015). Cognitive load of critical thinking strategies. *Learning and Instruction*, *35*, 51–61. https://doi.org/10.1016/j.learninstruc.2014.09.004

Sugiyono. (2017). *Metode penelitian kuantitatif, kualitatif dan R&D*. Alfabeta.

Tania, R., & Jumadi. (2020). The application of physics learning media based on android with learning problem based learning (PBL) to improve critical thinking skills. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences*

(ICRIEMS 2020), *528*, 583–590. https://doi.org/10.2991/assehr.k.210305.085

Tekkaya, C., Özkan, O., & Sungur, S. (2001). Biology concepts perceived as difficult by turkish high school students. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *21*(21), 145–150.

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. ERIC. https://doi.org/10.1016/0022-4405(76)90066-2

Udo, M. E. (2010). Effect of guided-discovery, student-centred demonstration and the expository instructional strategies on students' performance in chemistry. *African Research Review*, *4*(4), 389–398. https://doi.org/10.4314/afrrev.v4i4.69237

Yuliana, Tasari, & Wijayanti, S. (2017). The effectiveness of guided discovery learning to teach integral calculus for the mathematics students of mathematics education Widya Dharma University. *Infinity Journal*, *6*(1), 01. https://doi.org/10.22460/infinity.v6i1.222

Zabit, M. N. M. (2010). Problem-based learning on students critical thinking skills in teaching business education in Malaysia: A literature review. *American Journal of Business Education (AJBE)*, *3*(6), 19–32. https://doi.org/10.19030/ajbe.v3i6.436

Zeidan, A. (2010). The relationship between grade 11 Palestinian attitudes toward biology and their perceptions of the biology learning environment. *International Journal Science and Maths Education*, *8*(7), 783–800.