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Android Based Module Development with Project- Based Learning Model on Immune System Materials to Improve Critical Thinking and Digital Literature Skills

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Abstract

Critical thinking skills and digital literacy are indispensable in 21st-century life. These two skills can be trained through a learning process that uses an Android-based module with a Project Based Learning model. This study aims to analyse the feasibility and effectiveness of android-based modules to improve critical thinking skills and digital literacy. This research is a research development or Research and Development (R&D). The development in this study uses the ADDIE model which consists of five stages, namely Analysis, Design, Develop, Implementation, and Evaluation. The data in this study are module validity, critical thinking skills, and digital literacy. The instrument used in this study consisted of a module validation sheet to measure the feasibility of the module, reasonable multiple-choice test questions to measure critical thinking skills, and an observation sheet to measure digital literacy. The results showed that: 1) the module was declared very valid with an average value of 86.35; 2) the module is declared effective in improving critical thinking skills which are indicated by the N-Gain value of 0.47 with moderate criteria; and 3) the module is declared effective in increasing digital literacy as indicated by the N-Gain value of 0.56 with moderate criteria.

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INTRODUCTION

In the 21st-century, every student is required to have various to be able to adapt and be responsive to changes. 21st-century skills that must be possessed by students include critical thinking skills and digital literacy.

Critical thinking skills are one of the important and fundamental skills in 21st-century learning (Partnership for 21st-century Learning, 2015). Critical thinking is important because it acts as a basis for students to decide and take action on the problems they face in everyday life. Thus, these skills need to be trained to students through the learning process. One of the learning approaches to develop critical thinking skills is by asking several questions, then linking them to the concepts that students have to find solutions to a problem (Tiruneh et al., 2017).

In addition to critical thinking, students must also have digital literacy. Digital literacy is the ability to use digital technology, communication equipment, and or computer networks to get the right information (Educational Testing Service, 2002). Lennon et al. (2003) added that in addition to the ability to use technological equipment, digital literacy also includes the ability to access, manage, integrate, and evaluate information as well as create new knowledge and communicate effectively through digital devices.

Digital literacy is very much needed in the era of the industrial revolution 4.0 because most of the work involves technological advances related to the internet (Hermann et al., 2015). Advances in information technology and the internet have caused the availability of digital information to be very abundant. Digital literacy will shape the character of students with critical and creative mindsets and views so that they are not easily consumed by provocative issues, become victims of hoax information, or victims of digital-based fraud.

Based on observations in five public high schools and five private high schools in the Pati district related to learning biology, information was obtained that the methods and learning media used by teachers did not facilitate students to think critically. This causes students' critical thinking skills to be low. In addition, the level of digital literacy of students is still limited to the ability to use smartphones to communicate and find learning resources without regard to whether the learning resources used can be trusted or not.

Based on these problems, it is necessary to develop learning media that can encourage students to develop critical thinking skills and digital literacy. The learning media that will be developed is an Android-based module by integrating the Project-Based Learning model because android is very commonly used by the public, especially students as learners in the millennium era who have a learning style that relies on technology and information, especially in online learning during the Covid-19 pandemic (Yuan et al., 2017; Susanti et al., 2019).

Android-based module developed with SmartApps Creator. SmartApps Creator has complete features so that it supports various types of formats. The output of SmartApps Creator is an app that is easy to download and install on smartphones, and can be used offline or online (SmartAppsCreator, 2017; Azizah, 2020; Hamid et al., 2021).

Android-based modules are developed by integrating the Project-Based Learning model. Project-based learning integrated into android-based modules can facilitate students to collaborate and develop higher-order thinking skills in solving problems related to everyday life, thus encouraging students to develop critical thinking skills and digital literacy (Eliana et al., 2016; Bustami et al., 2018; Sumarti et al., 2018; Sejati et al., 2021). Project-Based Learning provides direct and real experience for students to design and produce a product from a project that has been designed to enable students to develop their thinking skills in arguing, explaining, analysing and evaluating. Project-based learning facilitates higher levels of learning and focuses on concepts, and involves students in problem-solving to improve critical thinking skills and conceptual understanding (Hikmah et al., 2016; Wekesa & Ongunya, 2016; Kurniyanti et al., 2019).

The Project-Based Learning model can improve digital literacy by integrating project assignments based on information and communication technology. The application of Project-Based Learning that integrates technology and information in the form of making digital

posters and video presentations can effectively improve students' digital literacy skills so that they can carry themselves in the era of digital learning (Lestari & Prasetyo, 2019; Kustini et al., 2021; Faridah et al., 2022).

METHODS

This research is development research or Research and Development (Sugiyono, 2017). The product that will be developed in this research is an android-based module with a Project-Based Learning model on immune system material to improve critical thinking skills and digital literacy.

The development in this study uses the ADDIE model which consists of five stages, namely Analysis, Design, Develop, Implementation, and Evaluation (Branch, 2009). At the Analysis stage, the results are the needs of analysis, curriculum analysis, and student character analyses were obtained through interview and questionnaire techniques. At the Design stage, the module is compiled based on the findings at the Analysis stage. At the Develop stage, the module is made according to what was planned at the Design stage. Furthermore, product validation is carried out by material experts, media experts, and practitioners. After being validated and revised based on the comments and suggestions of the validator, the product was tested on a small scale at SMA Negeri 2 Pati using a questionnaire to determine the responses of teachers and students. In the Implementation stage, a wide-scale test was conducted at SMA Negeri 1 Jakenan in class XI IPA 2, XI IPA 3, and XI IPA 4. The wide-scale test used a one-group pretest-posttest design (Sugiyono, 2017). The instruments used are multiple-choice questions to measure critical thinking skills and observation sheets to measure digital literacy. at the beginning of learning, students are given pretest of critical thinking skill. then, giving treatment about carrying out learning using an Android-based module with a Project Based Learning model. At the end of the lesson, the teacher gives a post test of critical thinking skills. At the Evaluation stage, two types of evaluation were carried out, namely formative and summative. Formative evaluation is based on the results of validation and response to a small-scale test, while summative evaluation is carried out at the final stage of development to determine the effectiveness of the product based on the value of critical thinking skills and digital literacy.

The data analysis techniques carried out include: 1) module feasibility analysis based on the results of the validation and the results of the teacher and student response questionnaires; 2) analysis of the module effectiveness in improving students' critical thinking skills based on pretest-posttest scores and classical completeness; and 3) an analysis of the module effectiveness in improving digital literacy based on the results of initial and final observations.

RESULTS AND DISCUSSION

In this section, the results are presented and discussions are described as follows.

The results in this development research include 1) the feasibility of an android-based module with a Project-Based Learning model; 2) The effectiveness of android-based modules with Project-Based Learning models to improve critical thinking skills; and 3) The effectiveness of android-based modules with Project-Based Learning models to improve digital literacy.

Feasibility of Android-based Module with Project-Based Learning Model

The results on the feasibility of the module were obtained from the results of material validation and media validation, which are presented in Table 1.

Table 1. Results of Validation of Android-Based Modules

Validation	Components	Value (%)			Average	Criteria
		Expert 1	Expert 2	Practitioner		
Material	Content	93.33	76.67	90.00	86.67	SV
	Presentation	92.22	77.78	94.44	88.15	SV
	Language	100.00	72.50	85.00	85.83	SV
	Average	95.19	75.65	89.81	86.88	SV
Media	Display	84.29	88.57	87.14	86.67	SV
	Navigation	86.67	90.00	80.00	85.56	SV
	Latest technology	81.25	80.00	73.33	78.19	V
	Average	84.07	86.19	80.16	83.47	SV
Average					86.35	SV

Description: SV: Very Valid; V: Valid

After the validation test was carried out and revised based on comments and suggestions from the validator, the module was tested on a small scale. A small-scale test was conducted to determine the response of teachers and students to the appearance and content of the module, which was expressed in terms of practicality. The results of teacher and student responses are presented in Table 2.

Table 2. Questionnaire Results of Teacher and Student Responses to the Appearance and Content of the Module

Aspect assessed	Value (%)		Average	Criteria
	Teacher	Student		
Interest in module	84.00	84.67	84.34	SP
Contents of module material	82.86	83.65	83.26	SP
Language	86.67	82.78	84.73	SP
Device operation	80.00	75.74	77.87	P
Average	83.38	81.71	82.55	SP

Description: SP : Very Practical; P : Practical

Effectiveness of Android-based Modules to Improve Critical Thinking Skills

The effectiveness of the android-based module with the Project-Based Learning model to improve critical thinking skills was obtained based on the N-Gain values pre-test and post-test, which are presented in Table 3.

Table 3. Improving Critical Thinking Skills with the N-Gain Test

Class	Pretest average	Post Test Average	N-Gain	Criteria
XI IPA 2	53.47	75.51	0.47	Moderate
XI IPA 3	48.43	71.52	0.45	Moderate
XI IPA 4	50.15	74.34	0.49	Moderate
Average	50.68	73.79	0.47	Moderate

The effectiveness of the android-based module can also be seen from the classical completeness, which is presented in Table 4.

Table 4. Classical Learning Completion Results

Class	Number of students		Percentage (%)	
	Completed	Not Completed	Completed	Not Completed
XI IPA 2	27	9	75.00	25.00
XI IPA 3	26	8	76.47	23.53
XI IPA 4	26	7	78.79	21.21
Average			76.75	23.25

The Effectiveness of Android-based Modules to Improve Digital Literacy

The effectiveness of the Android-based module with the Project-Based Learning model to improve digital literacy is obtained based on the results of digital literacy observations, which are presented in Table 5.

Table 5. Digital Literacy Improvement with N-Gain Test

Class	Average		N-Gain	Criteria
	Early LD	Late LD		
XI IPA 2	42.76	75.89	0.58	Moderate
XI IPA 3	42.49	74.74	0.56	Moderate
XI IPA 4	45.67	74.62	0.53	Moderate
Average	43.64	75.08	0.56	Moderate

Based on the research results that have been presented, a discussion will be carried out as follows.

Feasibility of Android-based Module with Project-Based Learning Model

Judging from the validation of the material, the android-based module is stated to be very valid. The module material developed in this study is presented in a coherent, complete, contextual manner, there is integration between paragraphs, using communicative, effective, efficient language, according to the intellectual level and development of students, and adapted to learning objectives. This is in line with Sistyarini & Nurtjahyani (2017) which states that the module is said to be valid if it is following the learning objectives. Bustami et al. (2018) added that to achieve learning objectives, it can be done by applying contextual learning. The use of language in the module is important because the module will be easy to learn if it uses language that is communicative, simple, and adapted to the level of intellectual and emotional development (Asfiah et al., 2013; Sujiono & Widiyatmoko, 2014).

Judging from the media aspect, the android-based module is also stated to be very valid. The developed module has a very attractive and interactive display because it is equipped with various types of formats such as text, images, video, audio, insert webpages, and hyperlinks. This is because the android-based module in this study was developed using SmartApps Creator. Rasyid & Partana (2021) stated that the Android-based e-module developed with SmartApps Creator was considered very feasible by media experts. In line with the research of Yuberti et al. (2021), the use of SmartApps Creator in developing mobile learning media also provides very feasible product validation results.

After being validated and revised based on comments and suggestions from the validators, the module was tested on a small scale to determine the teacher and student responses to the appearance and content of the module stated in practical terms. Based on Table 2, it can be seen that the module is stated to be very practical. The Android-based module developed with SmartApps Creator produces an output in the form of an application that is easy to download and install on a smartphone so that the module can be used anytime and anywhere both online and offline (SmartAppsCreator, 2017; Azizah, 2020). After being validated and revised based on comments and suggestions from the validators,

the module was tested on a small scale to determine the teacher and student responses to the appearance and content of the module stated in practical terms. Based on Table 2, it can be seen that the module is stated to be very practical. The Android-based module developed with SmartApps Creator produces an output in the form of an application that is easy to download and install on a smartphone so that the module can be used anytime and anywhere both online and offline (Ibrahim & Ishartiwi, 2017; Marhadini et al., 2017; Safitri et al., 2019; Budyastomo, 2020). An example of the display of the developed android-based module is presented in Figure 1.

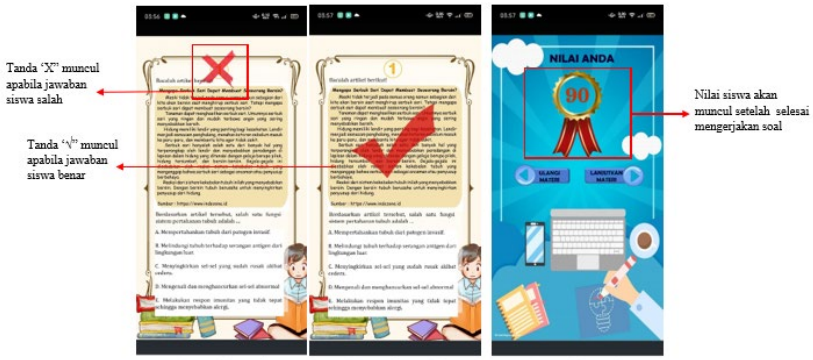

Figure 1. Competency Test packaged in the form of an interactive quiz

In addition to an attractive appearance and ease of operation, the module is said to be very practical because it integrates Project-Based Learning with project assignments in the form of digital posters. Learning activities that are following the Project-Based Learning syntax encourage the full involvement of students to find the material being studied for them, relate it to real life, and apply it in everyday life. Such learning activities can train students to develop critical thinking skills and digital literacy (Erstad, 2015; Efrimal et al., 2017; Bustami et al., 2018).

Based on the description above, it can be concluded that the Android-based module with the Project-Based Learning model is declared to be very valid and suitable for use in the learning process. These criteria are following the appearance and characteristics of the module.

Effectiveness of Android-based Modules to Improve Critical Thinking Skills

The effectiveness of the android-based module to improve critical thinking skills was obtained based on the value of the N-Gain pre-test and post-test. Based on Table 3, the N-Gain value is 0.47 with moderate criteria. The increase in critical thinking skills is due to the Android-based module being integrated with the Project-Based Learning model. The syntax in this learning model provides direct and real experience for students to play an active role and think critically in designing and producing a product from a project that has been designed.

The first syntax is Start with the Essential Question. At this stage, critical thinking skills developed is to provide simple explanations and build basic skills. Students are given essential questions related to contextual phenomena regarding the Covid-19 case to stimulate students' thinking skills in answering based on critical thinking and knowledge related to phenomena that occur in everyday life. Bustami et al. (2018) and Agoestanto et al. (2019) state that contextual problem-based learning can train students in giving arguments about a problem to form critical thinking skills.

The second syntax is Design a Plan for the Project. At this stage, critical thinking skills developed are to provide simple explanations, provide further explanations, and provide alternative problem-solving. At the stage of preparing the project plan, each group member can provide ideas, criticisms, and suggestions for solving problems related to the digital poster project that will be made. Rahayuni (2016) and Sumarti et al. (2018) states that critical, collaborative, and communicative thinking activities will bring up creative ideas in providing alternative solutions to a problem. When conveying creative ideas, students practice

analysing arguments to provide simple explanations or further explanations. Analysing arguments is one of the skills that critical thinkers must possess because it is an important part of critical thinking in making decisions, defending decisions, and influencing others (Farida, 2015; Agoestanto et al., 2019).

The third syntax is Create a Schedule and continues with project execution. At this stage, students' critical thinking skills will be more developed because students in groups must determine an action to complete a project. Each group must organize the work, divide the tasks according to the characteristics and talents of each member, and manage the time of the project so that it can be completed as planned. Woro (2015) and Mahasneh & Alwan (2018) state that in project-based learning, students will design their products and perform effective time management so that the product can be completed as specified. The learning process with peer groups through Project-Based Learning involves students collaborating in learning, discussing, and explaining their understanding and ideas. This is a factor that can develop problem-solving skills and support students' critical thinking (Kumar & James, 2015; Viro et al., 2020). After the project design and schedule have been compiled, the project implementation phase is continued. Project implementation begins with searching for information from various sources, namely Android-based modules, the internet, books, or other sources of information. In the process of searching for information or sources that are relevant to the project theme, students build basic skills in considering whether or not these sources of information can be used as reference material for making products. Furthermore, students are trained to develop the ability to conclude by summarizing the main ideas from several sources of information used in making projects.

The fourth syntax is monitoring the Student and the Progress of the Project. At this stage, the teacher supervises the project running process, while students will develop critical thinking skills through product creation. At this stage, critical thinking skills developed is to provide further explanation. This is closely related to the ability of students to solve problems experienced while completing projects. Students can solve problems if they can understand and translate the concept of the immune system in more depth (Wahyuni & Efuansyah, 2018).

The last syntax is Assess the Outcome and Evaluated the Experience. At this stage students make presentations to explain project results, discuss project results, and evaluate the advantages and disadvantages of the resulting project. Presentation activities encourage students to criticize, compare project results, and respond to student misconceptions through the evaluation process. This is supported by Osborne (2014) that the way to teach students' critical thinking skills is to involve students in criticizing, arguing, and asking questions.

Based on the description above, it can be concluded that the Android-based module with the Project-Based Learning model is declared effective for improving students' critical thinking skills. Project-Based Learning provides direct and real experience for students to design and produce a product to enable students to develop their thinking skills in arguing, explaining, analysing, evaluating, and determining solutions to problems that occur.

The Effectiveness of Android-based Modules to Improve Digital Literacy

The effectiveness of the android-based module to improve critical thinking skills is obtained based on the N-Gain value from digital literacy observations before and after implementing learning with android-based modules. Based on Table 3, the N-Gain value is 0.56 with moderate criteria. The increase in digital literacy is because the module developed in this study integrates information and communication technology which is packaged in the form of interactive learning media and can be used via Android. Digital literacy skills can be trained through direct learning using interactive learning media that is integrated with information and communication technology, for example, based on android (Kaeophanuek et al., 2018; Wahyudi, 2019; Aulia et al., 2019; Fatahillah et al., 2020; Rahmah et al., 2021).

The increase in students' digital literacy in this study was also due to the learning model used, namely Project-Based Learning. Project-based learning in this research directs students to

produce ICT-based products, namely digital posters, digital presentation materials, and methods of collecting project assignments that are carried out digitally. This is in line with Lestari & Prasetyo (2019) and Kustini et al. (2021) which states that the application of Project-Based Learning in the form of making digital posters and video presentations can effectively improve students' digital literacy skills. Dhayanti et al. (2018) also confirm that Project-Based Learning that is integrated with technology and information can improve students' ability to use digital devices. Students who have digital literacy will be able to carry themselves and compete in the era of digital learning (Faridah et al., 2022).

The use of Android-based modules with the Project-Based Learning model can train students to develop every aspect of digital literacy. The first aspect is defined, namely abilities related to the use of digital technology, network devices, and social networks (Educational Testing Service, 2002). In this study, the use of android-based modules requires students to use digital devices in the form of android. The use of android-based modules is following the characteristics of students who live in the digital era. Students as millennial learners who live in the digital era, have a learning style that relies on information and communication technology to allow the existence of android-based modules to be more practical (Yuan et al., 2017; Susanti et al., 2019).

Digital literacy is not limited to mastering the use of digital devices but includes information literacy. Information literacy is the ability to use digital media to access, manage, integrate, and critically evaluate the information obtained (Lennon et al., 2003). All Project-Based Learning activities contained in android-based modules direct students to be directly involved in digital literacy activities. Greaves et al. (2012) and Lubis et al. (2018) stated that students who get direction and guidance during their learning journey and are directly involved in digital activities have digital literacy skills that continue to increase.

In the process of working on a project, students access information from various digital sources. Ease of access and the abundance of information that can be obtained through the internet require students' critical thinking to select and determine reliable sources of information. In this case, digital literacy skills can help students to filter, summarize, and to conclude information from various sources, as well as provide alternatives to information that has been confirmed to be false so the student can avoid hoax news (Educational Testing Service, 2002; Stefany et al., 2017; Sabrina, 2019).

Digital literacy also includes the ability to produce information (create) and present information (communicate) in a digital scope. In the process of making a project, students determine the digital application that will be used to create a digital poster and then present it through digital media. This kind of activity is in line with Lubis et al. (2018) and Kustini et al. (2021) which state for example based on android (Kaeophanuek that Project-Based Learning in the form of project assignments for making digital posters affects student creativity and increases digital literacy in the aspect of communicating products through digital media.

Based on the description above, it can be concluded that the Android-based module with the Project-Based Learning model is declared effective for improving students' digital literacy. Project assignments contained in the module are assignments that are integrated with information and communication technology to encourage students to be directly involved in digital activities.

CONCLUSION

Based on the results and discussion, it can be concluded that the android-based module with the Project-Based Learning model on the developed immune system material is declared to be very valid and practical so that it can be used as a learning medium. Project-Based Learning contained in android-based modules encourages students to be directly involved in learning so that they can effectively improve critical thinking skills and digital literacy.

REFERENCES

Agoestanto, A., Sukestiyarno, Y. L., Isnarto, Rochmad, & Permanawati, F. I. (2019). Kemampuan Menganalisis Argumen dalam Berpikir Kritis Ditinjau dari Rasa

Ingin Tahu. *Prisma: Prosiding Seminar Nasional Matematika*, *2*, 337–342.

Asfiah, N., Mosik, & Purwantoyo, E. (2013). Pengembangan Modul IPA Terpadu Kontekstual pada Tema Bunyi. *USEJ: Unnes Science Education Journal*, *2*(1), 188–195.

Aulia, S. C., Rusilowati, A., & Wahyudin, A. (2020). Development of Unity 3D Learning Media to Increase Students' Learning Outcomes and ICT Literacy. *Journal of Primary Education*, *9*(3), 307–313.

Azizah, A. R. (2020). Penggunaan Smart Apps Creator (SAC) untuk Mengajarkan Global Warming. *Prosiding Seminar Nasional Fisika (SNF) Unesa*, *4*(2), 72–80.

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer US.

Budyastomo, A. W. (2020). Gim Edukasional untuk Pengenalan Tata Surya. *Teknologi: Jurnal Ilmiah Sistem Informasi*, *10*(2), 55–66.

Bustami, Y., Syafruddin, D., & Afriani, R. (2018). The Implementation of Contextual Learning to Enhance Biology Students' Critical Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 451–457.

Dhayanti, D., Johar, R., & Zubainur, C. M. (2018). Improving Students' Critical and Creative Thinking through Realistic Mathematics Education using Geometer's Sketchpad. *JRAMathEdu: Journal of Research and Advances in Mathematics Education*, *3*(1), 25–35.

Educational Testing Service. (2002). *Digital Transformation: A framework for ICT literacy*. http://www.ets.org/Media/Tests/Information_and_Communication_Technology_Literacy/ictreport.pdf

Efrimal, F., Kurnia, N., & Wasidi. (2017). Penerapan Model Project Based Learning (PjBL) untuk Meningkatkan Kecermatan dan Kreasi Seni Rupa (Studi Pada Siswa Kelas XI SMA Negeri 3 Seluma). *DIADIK : Jurnal Ilmiah Teknologi Pendidikan*, *7*(2), 48–61.

Eliana, E. D. S., Senam, Wilujeng, I., & Jumadi. (2016). The Effectiveness of Project-Based e-Learning to Improve ICT Literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 51–55.

Erstad, O. (2015). Educating the Digital Generation: Exploring Media Literacy for the 21st Century. *Nordic Journal of Digital Literacy*, *12*(3), 85–102.

Farida, N. (2015). Analisis Kesalahan Siswa SMP kelas VIII dalam Menyelesaikan Masalah Soal Cerita Matematika. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *4*(2), 42–52.

Faridah, N. R., Afifah, E. N., & Lailiyah, S. (2022). Efektivitas Model Pembelajaran Project Based Learning terhadap Kemampuan Literasi Numerasi dan Literasi Digital Peserta Didik Madrasah Ibtidaiyah. *Jurnalbasicedu*, *6*(1), 709–716.

Fatahillah, A., Puspitasari, I. D., & Hussen, S. (2020). The Development of Schoology Web-Based Learning Media with GeoGebra to Improve the ICT Literacy on Quadratic Functions. *JRAMathEdu: Journal of Research and Advances in Mathematics Education*, *5*(3), 304–316.

Greaves, L., Bradley, C., & Holley, D. (2012). Learning Journeys: Exploring Approaches to Learner Digital Literacy Acquisition. *Enhancing Learning in the Social Sciences*, *4*(2), 1–17.

Hamid, N. H., Andriyanto, R. M. A., & Adi, T. T. (2021). Utilization of Smart Apps Creator (SAC) As Software in Making Music Learning Media Applications. *Jurnal Penelitian Musik*, *2*(2), 154–172.

Hermann, M., Pentek, T., & Otto, B. (2015). Design Principles for Industrie 4.0 Scenarios: A Literature Review. *Technische Universitat Dortmund*, *1*(1), 4–16.

Hikmah, N., Budiasih, E., & Santoso, A. (2016). Pengaruh Strategi Project Based Learning (PjBL) terhadap Kemampuan Berpikir Kritis Siswa Kelas XI IPA pada Materi Koloid. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(11), 2248–2253.

Ibrahim, N., & Ishartiwi, I. (2017). Pengembangan Media Pembelajaran Mobile Learning Berbasis Android Mata Pelajaran IPA Untuk Siswa SMP. *Refleksi Edukatika : Jurnal Ilmiah Kependidikan*, *8*(1), 80–88.

Kumar.R, R., & James, R. (2015). Evaluation of Critical Thinking in Higher Education in

Oman. *International Journal of Higher Education*, *4*(3), 33–43.

Kurniyanti, R., Tri Martuti, N. K., & Alimah, S. (2019). The Effectiveness of Project Based Learning Ecosystems Dioramas with Jelajah Alam Sekitar Approach Against Students' Critical Thinking Ability and Creativity. *Journal of Biology Education*, *8*(3), 301–314.

Kustini, S., Herlinawati, & Indrasary, Y. (2021). Implementasi Pembelajaran Berbasis Project- Based Learning untuk Meningkatkan Keterampilan Literasi Digital Mahasiswa. *Jurnal INTEKNA*, *21*(1), 30–40.

Lennon, M., Kirsch, I., Davier, M. Von, Wagner, M., & Yamamoto, K. (2003). Feasibility Study for the PISA ICT Literacy Assessment: Report to Network A. In *Educational Testing Service*. http://eric.ed.gov/ERICWebPortal/recordDetail?accno=ED504154%5Cnpapers2://publication/uuid/DDEC9593-DBD8-4A73-8332-AC5CB5EB97D6

Lestari, D., & Prasetyo, Z. K. (2019). A Review on ICT Literacy in Science Learning. *Journal of Physics: Conference Series*, *1233*(1), 1–9.

Lubis, N., Lubis, A., & Ashadi, R. I. (2018). Integrating Teaching Models to Enhance Efl Students' Interpersonal Communication Skill and Creativity. *International Journal of Education & Literacy Studies*, *6*(4), 129–137.

Mahasneh, A. M., & Alwan, A. F. (2018). The Effect of Project-Based Learning on Student Teacher Self-Efficacy and Achievement. *International Journal of Instruction*, *11*(3), 511–524.

Marhadini, S. A. K., Akhlis, I., & Sumpono, I. (2017). Pengembangan Media Pembelajaran Berbasis Android pada Materi Laju Reaksi. *Unnes Physics Education Journal*, *6*(3), 38–43.

Osborne, J. (2014). Teaching Critical Thinking? New Directions in Science Education. *School Science Review*, *95*(352), 53–62.

Partnership for 21st Century learning. (2015). *21st CENTURY STUDENT OUTCOMES*. 1–9. http://www.p21.org/our-work/p21-framework

Rahayuni, G. (2016). Hubungan Keterampilan Berpikir Kritis dan Literasi Sains pada Pembelajaran IPA Terpadu dengan Model PBM dan STM. *Jurnal Penelitian Dan Pembelajaran IPA*, *2*(2), 131–146.

Rahmah, R., Susilo, H., & Yuliati, L. (2021). Pengembangan Media Interaktif Tema " Sehat itu Penting " untuk Meningkatkan Literasi Digital pada Kelas V Sekolah Dasar. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *6*(1), 70–78.

Rasyid, M. Al, & Partana, C. P. (2021). Pengembangan E-Modul Berbasis Android pada Materi Kesetimbangan Kimia untuk Peserta Didik SMA. *Jurnal Pendidikan*, *6*(4), 670–680.

Sabrina, A. R. (2019). Literasi Digital Sebagai Upaya Preventif Menanggulangi Hoax. *Communicare : Journal of Communication Studies*, *5*(2), 31–46.

Safitri, I., Pasaribu, R., Simamora, S. S., & Lubis, K. (2019). The Effectiveness of Android Application as a Student Aid Tool in Understanding Physics Project Assignments. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 512–520.

Sejati, D. J. W., Isnaeni, W., & Saptono, S. (2021). Analysis of High Level Thinking Skills, Character and Skills of Science Process of High School Students in Project Based Learning. *Journal of Innovative Science Education*, *10*(2), 183–192.

Sistyarini, D. I., & Nurtjahyani, S. D. (2017). Analisis Validitas terhadap Pengembangan Handout Berbasis Masalah pada Materi Pencemaran Lingkungan Kelas VII SMP / MTS Analysis of The Validity of the Development of Problem Based Handout on Environmental Content Chapters Class VII SMP / MTS. *Proceeding Biology Education Conference*, *14*(2014), 581–584.

SmartAppsCreator. (2017). *Smart Apps Creator Easiest Way To Design*. https://smartappscreator.com/index.php?m=Wapps&a=index

Stefany, S., Nurbani, & Badarrudin. (2017). Literasi Digital dan Pembukaan Diri: Studi Korelasi Penggunaan Media Sosial pada

Pelajar Remaja di Kota Medan. *Sosioglobal: Jurnal Pemikiran Dan Penelitian Sosiologi*, *2*(1), 10–31.

Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Sujiono, & Widiyatmoko, A. (2014). Pengembangan Modul IPA Terpadu Berbasis Problem Based Learning Tema Gerak untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *USEJ - Unnes Science Education Journal*, *3*(3), 685–693.

Sumarti, S. S., Aris, S. R. S., & Aini, R. N. (2018). Chemoentrepreneurship With Cooperative Integrated Process Inquiry Strategy to Increase Entrepreneurial Interest and Learning Motivation. *Jurnal Pendidikan IPA Indonesia*, *7*(2), 172–180.

Susanti, Hakim, L., Widayati, I., & Pratiwi, V. (2019). Students' Perspectives: ICT Usage in Vocational Education and Training (VET). *Advances in Social Science, Education and Humanities Research*, *335*, 205–210.

Tiruneh, D. T., De Cock, M., Weldeslassie, A. G., Elen, J., & Janssen, R. (2017). Measuring Critical Thinking in Physics: Development and Validation of a Critical Thinking Test in Electricity and Magnetism. *International Journal of Science and Mathematics Education*, *15*(4), 663–682.

Viro, E., Lehtoncn, D., Joutscnlahti, J., & Tahvanainen, V. (2020). Teachers' Perspectives on Project Based Learning in Mathematics and Science. *European Journal of Science and Mathematics Education*, *8*(1), 12–31.

Wahyudi, D. (2019). Pengembangan E-Modul dalam Pembelajaran Matematika SMA Berbasis Android. *GAUSS: Jurnal Pendidikan Matematika*, *2*(2), 1–10.

Wahyuni, R., & Efuansyah, E. (2018). Model Pembelajaran Missouri Mathematics Project (MMP) Menggunakan Strategi Think Talk Write (TTW) Terhadap Kemampuan Berpikir Kritis dan Kemampuan Pemecahan Masalah. *JNPM:Jurnal Nasional Pendidikan Matematika*, *2*(1), 24–36.

Wekesa, N. W., & Ongunya, R. O. (2016). Project Based Learning on Students' Performance in the Concept of Classification of Organisms Among Secondary Schools in Kenya. *Journal of Education and Practice*, *7*(16), 25–31.

Woro, S. (2015). The Strengths and Weakness of the Implementaion of Project Based Learning. *International Journal of Science and Research (IJSR)*, *4*(3), 478–484.

Yuan, K. S., Wu, T. J., Chen, H. B., & Li, Y. Bin. (2017). A Study on the Teachers' Professional Knowledge and Competence in Environmental Education. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(7), 3163–3175.

Yuberti, Wardhani, D. K., & Latifah, S. (2021). Pengembangan Mobile Learning Berbasis Smart Apps Creator sebagai Media Pembelajaran Fisika. *Physics and Science Education Journal (PSEJ)*, *1*(2), 90–95.