Improve Critical Thinking Skills with Informatics Educational Games

Samin[1*], Gunarhadi[2], Agus Efendi[3] ⓘD
[123]Faculty of Teacher Trainning and Education, Sebelas Maret, Surakarta, Indonesia

A R T I C L E   I N F O

A B S T R A K

Menghadapi tantangan abad ke-21 Kemampuan Berpikir kritis merupakan salah satu kemampuan uatama yang harus dimiliki siswa. Permasalahan rendahnya kemampuan berpikir kritis ditimbulkan oleh faktor dalam diri siswa dan pembelajaran yang kurang memfokuskan pada pengembangan kemampuan berpikir kritis. Penelitian ini bertujuan mengembangkan game edukasi Informatika dengan konten soal higher order thinking skill (HOTS) berbasis Soal kompetisi Berbras untuk meningkatkan kemampuan berpikir kritis siswa. Desain penelitian yang digunakan model ADDIE terdiri dari tahap analysis, design, develop, Implementation, evaluation. Uji Efektifitas game edukasi menggunakan Penelitian eksperimen dengan Nonequivalent Control Group Design. Subjek penelitian adalah kelas VIIA sebanyak 32 siswa dan Kelas VIIB sebanyak 33 siswa. Pengumpulan data menggunakan instrument kuesioner dan tes esai. Data hasil penelitian dianalisis menggunakan paired samples test, dengan persyaratan data berdistribusi normal dan homogen. Hasil uji normalitas dan homogenitas data, diperoleh taraf signifikansi lebih besar dari 0,05 sehingga data kemampuan berpikir kritis berdistribusi normal dan homogen. Peningkatan kemampuan berpikir kritis dari analisis N-Gain kelas eksperimen sebesar 0,63 dengan kategori sedang dan kelas kontrol sebesar 0,43 dengan kategori sedang. Berdasarkan hasil uji paired samples test diperoleh nilai Sig. (2-tailed) sebesar 0,000 < 0,05, dapat disimpulkan bahwa penggunaan game edukasi informatika berpengaruh signifikan terhadap peningkatan kemampuan berpikir kritis siswa.

A B S T R A C T

Facing the challenges of the 21st century Critical thinking is one of the main abilities that students must have. The problem of low critical thinking skills is caused by factors in students and learning that does not focus on developing critical thinking skills. This study aims to develop an Informatics educational game with higher order thinking skill (HOTS) questions based on the Berbras competition to improve students' critical thinking skills. The research design used by the ADDIE model consists of the stages of analysis, design, develop, implementation, evaluation. Test the effectiveness of educational games using experimental research with Noneequivalent Control Group Design. The research subjects were 32 students in class VIIA and 33 students in class VIIB. Collecting data using a questionnaire instrument and an essay test. The research data were analyzed using paired samples test, with the data requirements being normally distributed and homogeneous. The results of the normality and homogeneity test of the data, obtained a significance level greater than 0.05 so that the critical thinking ability data is normally distributed and homogeneous. The increase in critical thinking skills from the N-Gain analysis of the experimental class was 0.63 in the medium category and the control class was 0.43 in the medium category. Based on the results of the paired samples test, the value of Sig. (2-tailed) of 0.000 <0.05, it can be concluded that the use of informatics educational games has a significant effect on increasing students' critical thinking skills.

1. INTRODUCTION

Facing the challenges of the 21st century, everyone must have critical thinking skills, knowledge and skills of digital literacy, information literacy, media literacy and mastering information and communication technology (Frydenberg & Andone, 2011; Gelen Assoc, 2018; Hidayatullah et al., 2021). The qualification of graduates' abilities in the skills dimension in Permendikbud No. 20 of 2016 concerning Graduate Competency Standards explained that students have the ability to think and act critically. Curriculum developed in the 21st century focuses on building knowledge and encouraging students to obtain meaningful information to develop new skills. Critical thinking is a part of 21st century learning skills. Critical thinking ability is a very important aspect in education that must be developed in facing the challenges of the 21st century. Critical thinking is a directed and clear thinking process used in problem solving, decision making, analyzing and conducting scientific research. Critical thinking skills are rational (reasonable) and reflexive thinking skills that focus on

beliefs and decisions to be made (Ennis, 2011; Rahman, 2019; van Laar et al., 2019). In Informatics learning, teachers have tried to implement a scientific approach. However, the learning process is not optimal and has several obstacles due to low thinking skills, especially critical thinking skills (Fadillah, 2014; Szabo et al., 2020). Based on observations and experiences of teaching Informatics in class VII, the authors observe that low critical thinking skills are indicated in learning activities, namely in the questioning learning step, students still have difficulty in formulating hypothetical questions based on observations of the phenomenon of computational thinking. Factors that cause low critical thinking skills are: students are not trained to involve critical thinking processes in answering questions that are commonly used do not meet critical thinking indicators tend to have low cognitive levels, students are accustomed to rote questions that have low cognitive levels, so that their critical thinking skills are not honed, the teacher is used to giving examples of questions before the test so that students have difficulty if they are given questions in different forms (Astuti et al., 2019; Hussin et al., 2019; Rahman, 2019).

Learning that is oriented towards critical thinking skills needs to be continuously empowered by teachers, because critical thinking is a fundamental skill that must be possessed by every student like reading and writing skills. Today students have grown and developed with digital games. Their exposure to the internet and other digital media has shaped how they learn and receive information (Blumberg & Fisch, 2013; Buck, 2017; Li & Chu, 2021). Critical thinking skills are very important to have, because critical thinking can be used to solve problems and as a consideration in making correct decisions. Critical thinking is a process, aimed at making reasonable decisions about what to believe and what to do. In the learning process, students' thinking skills can be developed by enriching meaningful experiences through problem solving in class (Antara & Dewantara, 2022; Masterson, 2020; Supandi & Senam Senam, 2019). The learning process is built based on certain learning strategies. The strategy is in the form of a synthesis of the steps of learning activities, methods, media and tools as well as organized time to present learning content towards the achievement of predetermined learning objectives (Najmuddin & Aprilianty, 2020; Susilawati et al., 2019; Sutiani et al., 2021). In the teaching and learning process the teacher must be able to use the right media so that students are motivated to follow the teaching and learning process so that students will easily accept and remember the material that has been received.

Teachers can take advantage of the development of digital technology such as multimedia software to create interactive, attractive, and flexible educational game media in optimizing and empowering students' critical thinking skills in a fun way (Blumberg & Fisch, 2013; Griffiths, 2002). Educational games are games designed to focus on students as active users, so that they can involve them in collaborative activities in developing problem solving strategies and skills in decision making as an important component of learning stated that games are more interesting than conventional teaching and knowledge retention is longer by using games. Adventure-themed educational games encourage creative problem-solving and decision-making strategies. This kind of game also fosters skills in investigation that involve higher order thinking skills (Mee Mee et al., 2020; Peterson et al., 2009). The Android-based educational games developed are practically used as learning media (Rachma et al., 2020; Suci et al., 2019). Learning media that is in accordance with technological developments and according to the expectations of the 2013 curriculum is computer-based learning media. Information and communication technologies provide significant future opportunities for educational programs. It also provides advantages and becomes an effective tool for the development of new techniques and methods (Pekdağ, 2010; Sulaiman & Ismail, 2020; Suwartono & Aniuranti, 2019).

Educational games are declared very feasible to be used as learning media with a validation percentage reaching 81.82% and can also increase student interest in learning because from the results of the percentage of student interest in educational games reaching 50% in the very high category and 47.06% in the high category (Koriaty & Agustani, 2016; Suastra et al., 2019). Students with the lowest level of critical ability are limited to memorizing skills without being able to understand concepts well. Another factor that causes students' critical thinking ability is still low is that students are not trained and are not accustomed to answering questions with questions that present phenomena. This is also in accordance with the opinion that state to develop students' critical thinking skills can be done by always asking and question phenomena a is being studied (Anggareni et al., 2013). On the research state that the RPG-type android mobile learning media could improve students' critical thinking skills. This is in line with (which states that android-based learning media can improve students' critical thinking skills (Rasyid et al., 2020). Android-based educational games can train creative thinking skills (Prastyo et al., 2020; Sanusi et al., 2020; Widiyatmoko, 2021). Referring to several previous studies on the development of educational games that have been studied by researchers, educational games have been proven to be used as learning media. However, the development of educational games used in Informatics learning is mostly still used as a learning medium and only to attract students' interest in learning. The development of educational games in Informatics learning will be more focused on efforts to train critical thinking skills. Therefore, the researchers took the initiative to develop educational games which, apart from being valid and practical to be used as learning media, are also expected to be effective in training students' critical thinking

skills in learning Informatics. The description above is an important part as well as the reason for choosing the research title. The title of this research is Improve Critical Thinking skill with Informatics Educational Game.

2. METHOD

This study uses the Research and Development (R&D) method, according to Sukmadinata (2016) consisting of 3 stages, namely 1) Preliminary study, 2) Product development, 3) Testing. The procedure for developing this research is a procedural model which is modified from the ADDIE development model. ADDIE model research includes the stages of analysis (analyze), design (design), develop (develop) Implementation (application) and evaluation (evaluate). The subjects in this study were students of class VIIA and VIIB of MTsN 4 Karanganyar in the odd semester of the 2021/2022 school year in November and December 2021. The object of the research was students' critical thinking skills on Computational Thinking material. The experimental design used in this research and development uses the Noneequivalent Control Group Design. In this study there will be two groups that are not chosen randomly (Sugiyono, 2017). Both were then given a pretest to determine the initial state and the difference between the experimental group and the control group. A good pretest result is when the value of the experimental group in the control group is not significantly different. In this design, there are two groups, namely the experimental group, namely Class VIIA and Class VIIB as the control group. The research design described in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X_e	O_2
Control	O_3	X_k	O_4

Description : O_1 = *Pretest* result group experiment; X_e = Learning using Educational Games; $O2$ = *Posttest* Results _ Group Experiment; O_3 = *Pretest* result group control; X_k = Learning By conventional by the teacher O_4 = *Posttest* Results Group Control

Data analysis is carried out to test hypotheses in order to draw conclusions to achieve research objectives, data analysis is a way to process research data in order to obtain a conclusion. Collecting data by giving pretest and posttest questions to the experimental group and control group, and using student response questionnaires to obtain data from the experimental group after using informatics educational games. The learning carried out in the classroom uses a problem based learning learning model, with the steps (1) providing orientation about problems to students, (2) organizing students about learning tasks related to problems, (3) guiding student investigations individually or in groups, (4) develop and present reports on the results of activities, and (5) analyze and evaluate the problem solving process. The learning steps in the experimental class are facilitated by informatics educational game media created using Construct 2 software.

Informatics educational game learning media before being implemented in learning, first tested its effectiveness or validated by material experts and media experts, using a questionnaire that was reviewed in terms of material and media. Aspects of the effectiveness assessment in terms of material include the relevance of the material, the subject matter, and the suitability of the presentation with the demands of student-centered learning. Aspects of the effectiveness assessment in terms of media include the appearance of the educational game interface, the overall usefulness of educational games, and the overall attractiveness of educational games.

The Informatics educational game "Critical Thinking Adventure" which was developed is a new educational game, because it contains two games at once, the first is the COVID Mode in the form of a student adventure during the COVID-19 pandemic which is divided into three levels, Beginner, Intermediate and Advanced; and the second is the CT Adventure mode in the form of an adventure to get treasure in the form of solving "computational thinking" questions combined with HOTS questions and based on "Berbras" questions that prioritize computational thinking which is divided into two levels. The display of the "Critical Thining Adventure" Game design image developed in this research are show in Figure 1.

The tool used in data collection in this study was a critical thinking ability test, in the form of 8 essay questions. The critical thinking ability test serves to measure students' critical thinking skills before and after treatment, this test is given at the pretest and posttest. The effect of differences in treatment using Informatics educational games in improving critical thinking skills was analyzed from the results of the pretest and posttest in the experimental and control classes. To find out whether there is a significant difference between the results of the pretest and posttest of critical thinking skills, the pretest and posttest data were tested using a paired sample test, provided that the data were normally distributed and homogeneous. The data is normally distributed if the amount of data above and below the average is the same. Homogeneous data shows that the data variance

is homogeneous (Jaya, 2018). Analysis of data normality used the Kolmogorov-Smirnov and Shapiro-Wilk tests, while the analysis of data homogeneity used Levene Statistics with the help of the IBM SPSS version 22.0 application. The results of the test data are said to be normally distributed and homogeneous if the significance value is greater than 0.05 at the 5% significance level. Hypothesis testing is done by looking for the difference between the average pretest and posttest scores. If there is a difference, it means that the treatment given affects students' critical thinking skills. The decision criterion H0 is rejected if the significance value (2-tailed) is less than 0.05 at the 5% significance level. Data analysis is carried out to test hypotheses in order to draw conclusions to achieve research objectives, data analysis is a way to process research data in order to obtain a conclusion. Collecting data by giving pretest and posttest questions to the experimental group and control group, and using student response questionnaires to obtain data from the experimental group after using the informatics educational game "Critical Thinking Adventure".

Figure 1. Initial Appearance of the Game Critical Thining Adventure

3. RESULT AND DISCUSSION

Result

This research was conducted in the era of the COVID-19 Pandemic with teaching and learning activities with a system of 50% online and 50% offline. The purpose of this research is to develop and produce an educational game "Critical Thinking Adventure" that is suitable for use in learning Informatics in the material for Computational Thinking of SMP/MTs class VII. The final result of this product is the Informatics educational game "Critical Thinking" on the material for Computational Thinking of SMP/MTs class VII. Informatics educational game "Critical Thinking adventure" is used to facilitate student investigation activities in groups. This game can be played on Android-based smartphones, personal computers (PCs) or windows-based laptops. This educational game as a whole contains learning materials, practice questions, competencies and educational games. This educational game is a new development that contains two games at once, the first game is COVID Mode in the form of student adventures to save themselves from the COVID-19 outbreak during the COVID-19 pandemic by collecting Vitamins, Masks, Vaccine Injections, Hasmat clothes protectors, which are divided into three Beginner, Intermediate and Advanced levels. While the second game is the CT Adventure mode in the form of an adventure to get treasure in the form of solving "computational thinking" questions combined with HOTS questions and based on "Berbras" questions that prioritize computational thinking which is divided into two levels, the Beginner level consists of 10 Adventures and the Advanced Level consists of 10 adventure. This game is played by moving the player using the up, down, right and left arrows.

The content of questions in the Informatics Game in CT Adventure Mode starting from the level of understanding, application, analysis, to evaluation as a form of obstacle in the game aims to develop students' critical thinking skills, namely on indicators of focusing questions, analyzing arguments, providing further explanations, and making decisions. . The results of solving obstacles in the Informatics educational game in the form of answers to questions will then be assessed using the critical thinking ability rubric. Based on the results of an assessment using an effectiveness questionnaire from a material expert, it shows that overall from the aspect of adventure educational game material it is very effective and can be used without requiring revision. The results of the effectiveness questionnaire are presented in Table 2.

Table 2. Assessment Results Appropriateness Theory

Aspect	Average Score	%	Category
Learning	4.83	96.67	Very Effective
Contents _	4.75	95.00	Very Effective
Presentation	4.67	93.33	Very Effective
Effectiveness	4.75	95.00	Very Effective
Average	4.75	95.00	Very Effective

Table 2 shows that the informatics educational game developed is in accordance with the core competencies, basic competencies, indicators and learning objectives to be achieved. After going through the revision stage, an assessment of the game is carried out. The results of the assessment provide direction for the initial results of this media that was developed to obtain a value of 4.75 with a very effective category. Based on this assessment, 4 aspects of the feasibility of the material have been met.

Table 3. Assessment Results Media Eligibility

Aspect	Average Score	%	Category
Appearance design	4.60	92.00	Very Effective
Instruction	4.50	90.00	Very Effective
Writing	4.67	93.33	Very Effective
Voice	5.00	100	Very Effective
Convenience Use	4.50	90.00	Very Effective
Average	4.65	93.00	Very Effective

Based on Table 3, it can be seen that the Informatics educational game developed is in the very good category with an average score of 4.65 and an assessment percentage of 93%. Some aspects that have not been met are given input/suggestions from media expert lecturers. The validation of the critical thinking question instrument was carried out by a professional teacher colleague in the field of informatics. The results of the test instrument validation are presented in Table 4.

Table 4 . Results Validation Question Think Critical

No	Aspect Evaluation	Question Think Critical (%)							
		1	2	3	4	5	6	7	8
1	Contents	88	96	98	88	93	88	83	96
2	Construction	100	100	100	100	100	90	90	100
3	Language	92	92	100	85	100	92	93	93
	Average	**93.3**	**96.0**	**99.3**	**91.0**	**97.7**	**90.0**	**88.7**	**96.3**

Based on Table 4, these results indicate that each critical thinking item has met the validity criteria and can be used in research without requiring revision, both in terms of content, construction, and language. The increase in critical thinking skills can be determined from the normalized gain value (N-Gain) of 0.63 in the medium category. In summary, the results of data processing are presented in Table 5.

Table 5. Score Average Test Ability think critical

Component	Experiment Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Average score	60.81	85.65	60.00	78.59
Gain Score	0.63		0.43	
Category	Currently		Currently	

Base on Table 5, the average gain score of students' critical thinking skills at MTsN 4 Karanganyar in the experimental class was 0.63 which was included in the medium category and in the control class was 0.43 which was included in the medium category. The increase in critical thinking skills can be determined from the normalized gain value (N-Gain) of 0.63 in the medium category. To find out whether there is a significant difference or not, the pretest and posttest data were tested with paired samples test, preceded by normality and homogeneity tests of critical thinking ability data. During the limited trial, it was seen that the average score of student responses to the games developed in the field trial was in the very good category. The normality test is show in Table 6.

Table 6 Normality Test Results

		Kolmogorov-Smirnov [a]			Shapiro-Wilk		
		Statistical	df	Sig.	Statistics	df	Sig.
Critical Thinking skill	*Posttest*	*0.210*	31	0.001	0.934	31	0.056
	Pretest	*0.198*	32	0.003	0.914	32	0.015

Based on Table 6, the results of the data normality test using the Kolmogorov-Smirnov and Shapirowilk statistics, it is known that the significance value of the posttest and pretest data is greater than 0.05. So, critical thinking ability data is data that is normally distributed. Homogeneity test results is show in Table 7.

Tabel 7. Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
0.381	1	61	0.540

Based on Table 7, the results of homogeneity test it is known that the sig is 0.540. For the paired samples test results is show in Table 8.

Tabel 8. Paired Samples Test Results

	Mean	Std. Deviation	Std. Error Mean	Interval of the Difference		t	df	Sig.
				Lower	Upper			
Pretest--Posttest	-21.667	6.091	.767	-23.133	-20.133	-28.235	62	0.000

Base on Table 8, the results of the paired samples test show that the value of Sig. (2-tailed) of $0.000 < 0.05$. This means that there is a significant difference between critical thinking skills in the pretest and posttest data, which means that there is an effect of using Informatics educational games on the critical thinking skills of grade VII students. Based on expert judgments, media experts, students can conclude that this informatics educational game is appropriate to be used as a learning medium in informatics subjects for class VII students of MTs Negeri 4 Karanganyar.

Discussion

This research was conducted during the COVID-19 pandemic, the COVID-19 pandemic requires teachers to innovate in learning activities. The Covid-19 pandemic period is also the reason why teachers need to innovate in their learning activities, android-based games are one that can be used as learning innovations. Based on the results of the N-Gain analysis and paired samples test, it can be seen that the treatment using Informatics educational games has a significant effect on increasing students' critical thinking skills. The results of this study are relevant to the opinion of previous research which states that educational games require the involvement of students as active users in working together for the development of problem solving strategies and skills in decision making as an important component of learning (Aypay, 2016; Li & Chu, 2021). Decision making is the ability to think reflectively to determine what to do, as one of the elements of critical thinking skills.

Critical thinking will be easier to teach to students if it is included in courses/lessons, as opposed to practicing critical thinking independently through critical thinking courses (Chai & Kong, 2017; Ennis, 2011; Hussin et al., 2019). Critical thinking skills are very important to develop because students can more easily understand concepts, are sensitive to problems that occur so they can understand and solve problems, and are able to apply these concepts in different situations. According to previous research critical thinking skills can be trained with learning that requires students to carry out experimental activities, discover and solve problems as well as through discussion in small groups (Aini & Relmasira, 2018). Critical thinking skills can be trained through problem analysis, making decisions, trying to understand something, and finding answers to find answers to problems.

The strategies used to teach critical thinking skills include higher order questioning, cooperative learning, enrichment, modeling, real-life applications, and fostering affective domains. The strategies used include higher order questioning in the form of critical thinking questions, active learning by making students learn active independently, and enrichment by exposing students to problem solving in quizzes, materials and understanding the material with audiovisual and transfer processes through animation in Game (Chen & Chuang, 2021; Wardani et al., 2017). Educational games make students more comfortable

actively participating in learning because they are already familiar with the graphical environment in using computers. Through educational games, students not only understand the knowledge being taught, but also learn to develop competencies that will be useful for future careers, such as problem solving and critical thinking (Escudeiro et al., 2013; Li & Chu, 2021).

The results of research by reveal that the use of serious games can prepare students on an ongoing basis to face future challenges. This is due to the ability of serious games to transmit content and value in an attractive and efficient manner, improve information management skills, creativity, accuracy, and responsibility (Almeida & Simoes, 2019; Vieira et al., 2019; Virvou et al., 2005). The use of games in learning causes most students to successfully improve their skills in terms of teamwork, creativity, problem solving, and initiative in achieving goals. stated that educational games can make students from various conditions focus and concentrate on tasks over a long period of time. Research also show that educational games make learning more fun and are in line with the principle of learning, namely supporting the development of skills and competencies rather than memorizing facts (Castillo-Cuesta, 2022; Kurniawati et al., 2020; Mira et al., 2020). According to previous research state that critical thinking skills can be developed through questioning techniques, the level of questions asked refers to higher cognitive levels such as analysis, synthesis, and evaluation (Astuti et al., 2019; Hussin et al., 2019; Rahman, 2019). The level and depth of students' thinking is directly proportional to the level of questions asked by the teacher. If students are involved in higher order thinking processes such as analyzing or synthesizing they must think critically. However, if students are involved in lower-level thinking processes such as understanding or remembering, they will not think critically.

The results of this study are in accordance with research conducted by previous research which explains that the use of computer-based games in learning has better effectiveness than conventional learning in terms of mastery of concepts and students' critical thinking skills (Sari & Saputro, 2014). This is also in accordance with research about Educational Game "The Rotation" is considered very good in increasing students' interest and critical thinking skills (Damarjati & Miatun, 2020). Furthermore, it was revealed An educational game called the "Linear Program Adventure" game can be said to be effective for training students' critical thinking skills. Likewise, the "Critical Thinking Adventure" educational game is also able to improve students' thinking skills in Informatics subjects.

Implication of this study the use of educational game media in this study provides its own excitement and fun for students in completing games interactively because they have the freedom to control the player (players) to collect scores, complete obstacles to maintain the player's life, and compete with other groups in completing the game in time. as soon as possible. The obstacles presented in this educational game are in the form of guiding questions that can be used as scaffolding to solve contextual problems presented by the teacher in the learning activities in the introduction. The correct answer to a question as a form of obstacle can increase the score in the game. However, giving the wrong answer can reduce the player's life. This situation certainly encourages students to be able to concentrate fully in solving every obstacle in the game so as not to fail (game over). Adventure educational games encourage student involvement in extra effort and focus on solving problems in defending the player's life.

4. CONCLUSION

The results of this study found that the Informatics educational game was feasible to use based on the review and validation of media experts and material experts. This educational game is very suitable for use in the Informatics learning process. Students gave a positive response to the use of this educational game, as well as to the implementation of learning using educational games that were considered suitable for the critical thinking ability of the experimental class students before and after the posttest experienced a significant difference. Based on the N-Gain analysis, the use of educational test games was proven to increase students' critical thinking ability scores in the medium category. This condition indicates that the use of informatics educational games has a significant effect on increasing students' critical thinking skills.

5. REFERENCES

Aini, Q., & Relmasira, S. C. (2018). Penerapan Pembelajaran Tematik Integratif Berbasis Kontekstual untuk Meningkatkan Keaktifan dan Hasil Belajar Siswa Kelas 1 SD. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *27*(2), 124–132. http://journal2.um.ac.id/index.php/sd/article/view/5359.

Almeida, F., & Simoes, J. (2019). The Role of Serious Games , Gamification and Industry 4 . 0 Tools in the Education 4 . 0 Paradigm. *Contemporary Educational Technology*, *10*(2), 120–136. https://doi.org/10.30935/cet.554469.

Anggareni, N. W., Ristiati, N. P., & Widiyanti, N. L. P. M. (2013). Implementasi strategi pembelajaran inkuiri

terhadap kemampuan berpikir kritis dan pemahaman konsep IPA siswa SMP. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, *3*(1). https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ipa/article/view/752.

Antara, I. G. W. S., & Dewantara, K. A. K. (2022). E-Scrapbook: The Needs of HOTS Oriented Digital Learning Media in Elementary Schools. *Journal for Lesson and Learning Studies*, *5*(1), 71–76. https://doi.org/10.23887/jlls.v5i1.48533.

Astuti, A. P., Aziz, A., Sumarti, S. S., & Bharati, D. A. L. (2019). Preparing 21st Century Teachers: Implementation of 4C Character's Pre-Service Teacher through Teaching Practice. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012109.

Aypay, A. (2016). Investigating The Role of Traditional Children's Games in Teaching Ten Universal Values in Turkey. *Eurasian Journal of Educational Research*, *62*, 283–300. https://doi.org/http://dx.doi.org/10.14689/ejer.2016.62.14.

Blumberg, F. C., & Fisch, S. M. (2013). Introduction: Digital games as a context for cognitive development, learning, and developmental research. *New Directions for Child and Adolescent Development, 139*, 1–9. https://doi.org/10.1002/cad.20026.

Buck, M. F. (2017). Gamification of Learning and Teaching in Schools – A Critical Stance. *Seminar.Net*, *13*(1). https://doi.org/10.7577/seminar.2325.

Castillo-Cuesta, L. (2022). Using Genially Games for Enhancing EFL Reading and Writing Skills in Online Education. *International Journal of Learning, Teaching and Educational Research*, *21*(1), 340–354. https://doi.org/10.26803/ijlter.21.1.19.

Chai, C. S., & Kong, S.-C. (2017). Professional learning for 21st century education. *Journal of Computers in Education*, *4*(1), 1–4. https://doi.org/10.1007/s40692-016-0069-y.

Chen, H., & Chuang, Y. (2021). The effects of digital storytelling games on high school students' critical thinking skills. *Journal of Computer Assisted Learning*, *37*(1), 265–274. https://doi.org/10.1111/jcal.12487.

Damarjati, S., & Miatun, A. (2020). Pengembangan Game Edukasi Berbasis Android sebagai Media Pembelajaran Berorientasi pada Kemampuan Berpikir Kritis. *ANARGYA: Jurnal Ilmiah Pendidikan Matematika*, *4*(2), 164–175. https://doi.org/10.24176/anargya.v4i2.6442.

Ennis, R. H. (2011). *The Nature of Critical Thinking: An Outline of Critikal Thinking Dispositions and Abilities.* University of Illinois.

Escudeiro, P. M., Escudeiro, N. F., Reis, R. M., Barata, A., & Vieira, R. (2013). Quality Criteria for Educational Games. *EAI Endorsed Transactions on Serious Games*, *1*(1). https://pdfs.semanticscholar.org/c05b/172c2ffca95c941ad6f684c3b3996f00d038.pdf.

Fadillah, M. (2014). *Implementasi Kurikulum 2013 Dalam Pembelajaran SD/MI, SD/MTS, dan SMA/MA*. Ar-Ruzz.

Frydenberg, M. E., & Andone, D. (2011). Learning for 21st Century Skills. *IEEE's International Conference on Information Society*, 314–318. https://doi.org/10.1109/i-Society18435.2011.5978460.

Gelen Assoc, I. (2018). Academicians' Predictions Of 21 St Century Education And Education In The 21 St Century. *European Journal of Education Studies*, *4*, 165–204. https://doi.org/10.5281/zenodo.1233478.

Griffiths, M. (2002). The educational benefits of video games. *Education and Health*, *20*(3), 47–51. https://doi.org/https://www.researchgate.net/publication/284491180.

Hidayatullah, Z., Wilujeng, I., Nurhasanah, N., Gusemanto, T. G., & Makhrus, M. (2021). Synthesis of the 21st Century Skills (4C) Based Physics Education Research In Indonesia. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(1), 88. https://doi.org/10.26737/jipf.v6i1.1889.

Hussin, H., Jiea, P. Y., Rosly, R. N. R., & Omar, S. R. (2019). Integrated 21st century science, technology, engineering, mathematics (STEM) education through robotics project-based learning. *Humanities and Social Sciences Reviews*, *7*(2), 204–211. https://doi.org/10.18510/hssr.2019.7222.

Jaya, I. (2018). *Penerapan Statistik Untuk Pendidikan*. Prenadamedia Group.

Koriaty, S., & Agustani, M. D. (2016). Pengembangan Model Pembelajaran Game Edukasi untuk Meningkatkan Minat Siswa Kelas X TKJ SMK Negeri 7 Pontianak. *Edukasi : Jurnal Pendidikan*, *14*(3), 277–288. https://doi.org/10.31571/edukasi.v14i2.360.

Kurniawati, D., Taufiq, M., Kasiyun, S., & Naufi'ah, N. (2020). Meta-Analysis of Teams Games Tournament Learning Model with Spinning Wheel Media-Based on Local Wisdom Toward Students' Learning Outcomes. *Journal of Education Research and Evaluation*, *4*(3), 296. https://doi.org/10.23887/jere.v4i3.28183.

Li, X., & Chu, S. K. W. (2021). Exploring the effects of gamification pedagogy on children's reading: A mixed-method study on academic performance, reading-related mentality and behaviors, and sustainability. *British Journal of Educational Technology*, *52*(1), 160–178. https://doi.org/10.1111/bjet.13057.

Masterson, M. (2020). An Exploration of The Potential Role of Digital Technologies for Promoting Learning in

Foreign Language Classrooms: Lessons for a Pandemic. *International Journal of Emerging Technologies in Learning*, *15*(14), 83–96. https://doi.org/10.3991/ijet.v15i14.13297.

Mee Mee, R. W., Shahdan, T. S. T., Ismail, M. R., Abd Ghani, K., Pek, L. S., Von, W. Y., Woo, A., & Rao, Y. S. (2020). Role of gamification in classroom teaching: Pre-service teachers' view. *International Journal of Evaluation and Research in Education*, *9*(3), 684–690. https://doi.org/10.11591/ijere.v9i3.20622.

Mira, M., Syihabudin, S., & Nurbayan, Y. (2020). Evaluation Of Arabic Learning Using The Kahoot Application In The Pandemic Era Of Covid-19. *Ta'lim Al-'Arabiyyah: Jurnal Pendidikan Bahasa Arab & Kebahasaaraban*, *4*(2), 153–164. https://doi.org/10.15575/jpba.v4i2.8930.

Najmuddin, H. A., & Aprilianty, L. (2020). The Analysis of Learning Strategies for Character Development of Students During Covid-19 Pandemic. *Jurnal Tatsqif*, *18*(2), 136–150. https://doi.org/10.20414/jtq.v18i2.2834.

Pekdağ, B. (2010). Alternative methods in learning chemistry: Learning with animation, simulation, video and multimedia. *Journal of Turkish Science Education*, *7*(2), 79–110. https://www.researchgate.net/profile/Pekdag-Buelent/publication/49607764_Alternative_Methods_in_Learning_Chemistry_Learning_with_Animation_Simulation_Video_and_Multimedia/links/5fd0b0b592851c00f85f50ec/Alternative-Methods-in-Learning-Chemistry-Learning-with-Animation-Simulation-Video-and-Multimedia.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail.

Peterson, S. J., Walumbwa, F. O., Byron, K., & Myrowitz, J. (2009). CEO Positive Psychological Traits, Transformational Leadership, And Firm Performance In High-Technology Start-Up And Established Firms. *Journal of Management*, *35*(2), 348–368. https://doi.org/10.1177/0149206307312512.

Prastyo, A. B., Gembong, S., Masfingatin, T., & Maharani, S. (2020). HOTS Android Based Student Worksheets to Practice Creative Thinking Ability of Vocational School Students. *Journal of Physics: Conference Series*, *1464*(1). https://doi.org/10.1088/1742-6596/1464/1/012006.

Rachma, Y. P., Setyadi, D., & Mampauw, H. L. (2020). Pengembangan Mobile Learning Barusikung Berbasis Android pada Materi Bangun Ruang Sisi Lengkung. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(3). https://doi.org/10.31980/mosharafa.v9i3.724.

Rahman, M. M. (2019). 21st Century Skill "Problem Solving": Defining the Concept. *Asian Journal of Interdisciplinary Research*, *2*(1), 64–74. https://doi.org/10.34256/ajir1917.

Rasyid, A., Gaffar, A. A., & Utari, W. (2020). Efektivitas Aplikasi Mobile Learning Role Pay Games (RPG) Maker MV Untuk Meningkatkan Kemampuan Berpikir Kritis. *Jurnal Mangifera Edu*, *4*(3), 129–142. https://doi.org/10.31943/mangiferaedu.v4i2.47.

Sanusi, A. M., Septian, A., & Inayah, S. (2020). Kemampuan Berpikir Kreatif Matematis dengan Menggunakan Education Game Berbantuan Android pada Barisan dan Deret. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(3), 511–520. https://doi.org/10.31980/mosharafa.v9i3.866.

Sari, K. W., & Saputro, S. (2014). Pengembangan Game Edukasi Kimia Berbasis Role Playing Game (RPG) pada Materi Struktur Atom Sebagai Media Pembelajaran Mandiri Untuk Siswa. *Jurnal Pendidikan Kimia*, *3*(2), 96–104. https://jurnal.fkip.uns.ac.id/index.php/kimia/article/view/3717.

Suastra, I. W., Ristiati, N. P., Adnyana, P. P. B., & Kanca, N. (2019). The effectiveness of Problem Based Learning - Physics module with authentic assessment for enhancing senior high school students' physics problem solving ability and critical thinking ability. *Journal of Physics: Conference Series*, *1171*(1). https://doi.org/10.1088/1742-6596/1171/1/012027.

Suci, N. W., Hobri, H., & Murtikusuma, R. P. (2019). Pengembangan Game Android Berbantuan Software Gamesalad Untuk Siswa SMP Materi Perbandingan. *Vygotsky : Jurnal Pendidikan Matematika Dan Matematika*, *1*(2), 65. https://doi.org/10.30736/vj.v1i2.131.

Sugiyono. (2017). *Metode Penelitian & Pengembangan. Research and Development. Untuk Bidang Pendidikan, Manajeman, Sosial, dan Teknik* (3rd ed.). Bandung: Alfabeta.

Sulaiman, J., & Ismail, S. N. (2020). Teacher competence and 21st century skills in transformation schools 2025 (TS25). *Universal Journal of Educational Research*, *8*(8), 3536–3544. https://doi.org/10.13189/ujer.2020.080829.

Supandi, M., & Senam Senam. (2019). Mengembangkan keterampilan berpikir kritis dengan Game ritual tumpe. *Jurnal Inovasi Pendidikan IPA*, *5*(2), 139–146. https://doi.org/10.21831/jipi.v5i2.25920.

Susilawati, W. O., Widodo, H., & Sumarno, S. (2019). Strategy of Teachers in Suporting Environmentally Sustainable Development. *Journal of Education and Learning (EduLearn)*, *13*(2), 247–254. https://doi.org/https://doi.org/10.11591/edulearn.v13i2.12167.

Sutiani, A., Situmorang, M., & Silalahi, A. (2021). Implementation of an Inquiry Learning Model with Science Literacy to Improve Student Critical Thinking Skills. *International Journal of Instruction*, *14*(2). https://doi.org/10.29333/iji.2021.1428a.

Suwartono, T., & Aniuranti, A. (2019). Digital Teaching Tools in 21st Century EFL Classroom: Are Our

Teachers Ready? *ELLITE: Journal of English Language, Literature, and Teaching*, *3*(2), 57. https://doi.org/10.32528/ellite.v3i2.1916.

Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability (Switzerland)*, *12*(23), 1–28. https://doi.org/10.3390/su122310113.

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2019). Determinants of 21st-century digital skills: A large-scale survey among working professionals. *Computers in Human Behavior*, 93–104. https://doi.org/10.1016/j.chb.2019.06.017.

Vieira, E. A. O., Silveira, A. C. D., & Martins, R. X. (2019). Heuristic evaluation on usability of educational games: A systematic review. *Informatics in Education*, *18*(2), 427–442. https://doi.org/10.15388/infedu.2019.20.

Virvou, M., Katsionis, G., & Manos, K. (2005). Combining Software Games with Education: Evaluation of its Educational. *Educational Technology & Society*, *8*(2), 54–65. https://www.jstor.org/stable/pdf/jeductechsoci.8.2.54.pdf.

Wardani, S., Lindawati, L., & Kusuma, S. B. W. (2017). The development of inquiry by using android-system-based chemistry board game to improve learning outcome and critical thinking ability. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 196–205. https://doi.org/10.15294/jpii.v6i2.8360.

Widiyatmoko, A. (2021). The effectiveness of google classroom as a tool to support online science learning: a literature review. *Journal of Physics: Conference Series*, *1918*(5), 52069. https://iopscience.iop.org/article/10.1088/1742-6596/1918/5/052069/meta.