

GOOPI (Game Open Online Physics Instructional) to Facilitating 21st-Century Skills (21-CS)

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Abstract

The purpose of this study was to explore characteristics of GOOPI (Game Open Online Physics Instructional) on the concept of heat transfer and its impact in facilitating 21st-Century Skills (21-CS) consist Critical Thinking, Collaboration, Communication, and Creativity. The method of this study qualitative research method with experimental case method with a sample size of 180 Indonesian students aged 15 to 17 years from 6 secondary schools was conducted to test the effectiveness of GOOPI. The results show that this GOOPI on URL <https://goopi.id> uses UC Browser of significantly improves 21-CS consist Critical Thinking, Collaboration, Communication, and Creativity. Furthermore, students' responses to learning with GOOPI showed a positive attitude and students looked challenged. In addition, this GOOPI is shown as a useful game learning tool and for exploration learning games that contain physics concepts. Furthermore, from the integration of GOOPI to facilitate 21-CS for physics education it can promote active participation and interaction, balancing learning goals with game.

Keywords: GOOPI (Game Open Online Physics Instructional), Facilitating, 21st-Century Skills (21-CS).

1. Introduction

Currently, the fast development of science and technology, especially in the field of information and communication technology, has an impact on various fields including education. Advances in Information Technology have driven many changes, including in the field of education (**Chauhan, 2016**). One of them is the emergence of multimedia as a learning medium. Various kinds of diverse technological advances can increase the interaction between teachers and students (**Otterborn, et al., 2018**). Higher education should make Independent Learning in the face of social change, the world of work and technological advances, in accordance with the needs of the industrial revolution era 4.0 (**Ahmad, 2019**); a link and match between researchers and the community or the world of work is necessary (**Jackson, 2019**). It is required to innovate and develop innovative learning at the same age as industry demands. This demand is in line with the target of achieving the learning achievement of the Higher education for Independent Learning curriculum (**Landry, 2019**) and problem-solving abilities (**Balta, & Asikainen, 2019**). Merdeka Learning or Independent Learning (IL) is a tangible

form of interesting learning challenges to create an innovative learning culture, and according to student needs (**Abidah, et al., 2020**). The world of education today requires students to be active in the learning process. The teacher is not the only source of learning, because the pattern of communication in learning is no longer one-way by placing the teacher as the only source of learning. The teacher's role is no longer as a presenter of information but has become a facilitator for the learning process (**Blasco, et al., 2020**).

A key word of classroom learning is successful motivation, unstoppable students (**Yin, et al., 2020**). Unfortunately, nowadays there is a lot of content that needs to be studied in class so that students do not directly motivate them in other words learning is "boring". In order not to be boring, students must be challenged to learn, this challenge can be directly orally. Today, students have a hobby of playing games (**Odewumi, et al., 2020**), so there is an idea how this game can be used as a motivating vehicle for learning (**Sousa, 2020**). Learning through the listening process without doing other things such as taking notes, it only contributes to the mastery of the material by 5%. If followed by reading, it contributes 10% mastery of concepts and when learning with audio-visual assistance, it will contribute to mastering the material by 30% (**Kåre&Sigbjørn, 2018**). The results of these studies indicate that if students can see the physical material visually, students will find it easier to understand and will avoid the construction of wrong conceptions.

In recent years, Game-Based Learning (GBL) has received significant attention from educators and researchers in learning (**Troussas, et la., 2020**). Games are an effective way to increase motivation(**Cahyana, et al., 2017**)and attract students to learn (**Chang, et al., 2019**) and can be seen as a form of game implemented in learning to improve thinking skills (**Yeh, et al., 2019**). Games are elements and principles of games in non-game contexts with the goal of increasing user engagement and productivity. The use of game design in education can provide an engaging and participatory framework for learning. Game-based learning has received significant attention in educational pedagogy as an effective way to increase student motivation and engagement (**Hadi, et al., 2019**).

The importance of preparing a flexible, creative, and proactive young generation through 21st century skills (**Meyer & Norman, 2020**). It is also increasingly realized that it is necessary to form children who are skilled in problem solving, wise in making decisions, think creatively, like to consult, can communicate ideas effectively, and are able to work efficiently both individually and in groups. 21st-century skills focus on innovation learning skills, namely (1) critical thinking and problem solving as expert thinking; (2) communication and collaboration as a complex form of communication; and (3) creativity and invention to apply imagination and the results of imagination or invention. These three skills are key in learning and become demands in the world of work. The world of education has a close relationship with various fields of development that are based on economic needs. There are 5 important competencies that connect the world of education and the world of work, namely, critical thinking, problem solving, technology and communication, collaboration, and independent skills (**Black, 2020**).

Digital competence is key in the types of skills and understanding students must have. Digital competence consists of information management, collaboration, communication and sharing, content and knowledge creation, ethics and responsibility, evaluation and problem solving and technical operations (**Sonia, et al., 2020**). The 21st-century skill categories are as follows: Ways of Thinking

(creativity and innovation; critical thinking, problem solving, and decision making; learning to learn and metacognition), Ways of Working (communication; collaboration and teamwork), Tools for Working (information literacy; literacy information and communication technology) and Living in the World (life and career; personal and social responsibility). So that facilitation is needed in the learning process that ensures students' mastery of 21st-century skills in the classroom as preparation for working life (**Ghafar, 2020**).

Media and technology are used as tools for visualizing the nature of the teaching and learning process to support educational goals such as skills to find and assess information, collaboration, communication, and problem solving that are important for student preparation so that they can encourage the learning process (**Hamadi, et al., 2021**). Learning media contributes to improving the quality and quality of learning(**Alaattin, 2014**). The presence of learning media not only helps teachers in delivering their teaching materials, but also provides added value to learning activities (**Williamson, et al., 2020**). This applies to all types of media, both sophisticated and expensive media, or simple and inexpensive learning media.

2. Significance of The Study

Learning through the listening process without doing other things such as taking notes, it only contributes to the mastery of the material by 5%. If followed by reading, it contributes 10% mastery of concepts and when learning with audio-visual assistance, it will contribute to mastering the material by 30%. The results of these studies indicate that if students can see the physical material visually, students will find it easier to understand and will avoid the construction of wrong conceptions.

GOOPI media has been developed by researchers for approximately 2 years in the multimedia laboratory of the State University of Jakarta, Indonesia. Researchers who are members of the Physics Education Research Agency (PER) have conducted a series of studies to examine the working principles of GOOPI (Open Online Physics Instructional Game) as a physics learning medium and can be accessed for free on the following page: <https://goopi.id> (UC browser) and has been published GOOPI (**Wibowo, et al., 2020**). GOOPI is effectively applied in physics learning, especially to help explain microscopic phenomena or abstract physics concepts (**Wibowo, et al., 2021**).

However, there has been a lot of research done on online games for learning, but these online games have not facilitated students to abstract phenomena. If microscopic phenomena are believed to be very helpful in the process of construction and reconstruction of conceptions in physics learning, especially for teaching materials that are unobservable. Therefore, researchers are interested in developing virtual online games that have not been developed by other researchers in the hope of making a real contribution to improving the quality of physics learning at various high school and college levels through the provision of one of the supporting tools for learning physics in the form of online instructional games.

3. Review of Related Studies

Digital Game-Based Learning helps train the brains of digital native children to change towards accommodating new technologies. Digital games as a new thing in the world of education because students start learning through games (**Wei & Yu, 2021**). The era of the industrial revolution 4.0

with all the new technological advances, I believe that conventional traditional games have been replaced by electronic games, and past games have been turned into games with a simulation environment. In addition, electronic games and simulations have started to become a necessity for learning in formal education. In addition, the millennial generation who is already present and has grown up and calls themselves the 'game generation' (Iqbal & Golombok, 2017). The gaming generation that plays a lot of games absorbs information faster. Therefore, the game generation is also always oriented towards solving intellectual problems.

Problem solving can be solved with a good education, because education has a strategic role to prepare young people who have high empowerment and emotional intelligence and master solid skills. This is nothing but preparing humans who meet the qualifications according to the demands of the times and today's society, better known as the challenges of the 21st-century (Meyer & Norman, 2020). The challenges of the 21st-century are marked by the acceleration of the development of science, technology and information and the absence of boundaries between "space and time" between countries that give rise to a free market. Therefore, the world of education must be ready to produce young people who are equipped with 21st-century skills (Buchanan, 2021).

4. Objectives of The Study

Based on the problems and solutions as described above, the researcher conducted a research entitled "GOOPI (Game Open Online Physics Instructional) to Facilitating 21st-Century Skills (21-CS)". The success of developing new GOOPI for microscopic physics materials and their effectiveness in helping to facilitate 21st-century skills, can be claimed as a novelty of this research.

5. Method

The method of this study qualitative research method with experimental design (Reichardt, 2019). Experimental method with a sample size of 180 Indonesian students aged 15 to 17 years from 6 secondary schools was conducted to test the effectiveness of GOOPI. Comparison of the number of samples 35% male and 65% female, with the mean age of the students was 16.24 years (SD=1.19). The Mann-Whitney test showed no significant relationship between age and gender ($Z = -0.59$, & $p < 0.57$).

The experimental group took the physics subject of the concept of heat transfer. The competence that is expected is that students can understand the characteristics of conduction, convection, and radiation. To see the impact of GOOPI, an evaluation was carried out on the experimental group and to control the achievement of 21st-Century Skills (21-CS): Critical Thinking, Collaboration, Communication, and Creativity. This 21-CS achievement uses previously validated Critical Thinking, Collaboration, Communication, and Creativity test instruments. All the tools used in data collection, application in learning and implementation in this study are shown in Figure 1.

Figure 1. Research Methods to Application of GOOPI

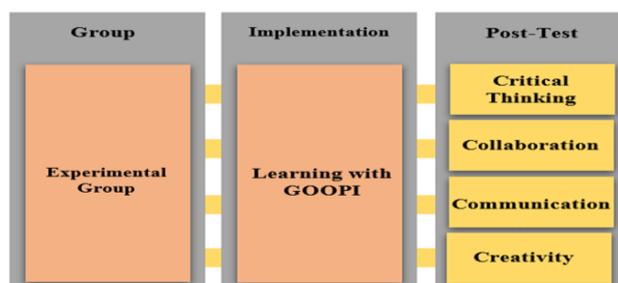


Figure 1 explains that this study was conducted with 6 secondary which is called the experimental group. This experimental group studied with GOOPI on the <https://goopi.id/> uses UC Browser page. After finishing the learning, a posttest was conducted using the Critical Thinking Test, Collaboration Test, Communication Test, Creativity Test to see the impact of GOOPI in learning to facilitate 21-CS.

6. Data Collection

In this study, quantitative and qualitative research methods to collect data, analyze, interpret, the findings. Data is collected in class online through the <https://goopi.id/> (UC Browser) platform, starting from observations, implementation of GOOPI and feedback completed by teachers and students. Post-test was conducted after implementation to measure 21st-Century Skills (21-CS): Critical Thinking, Collaboration, Communication, and Creativity. All learning implementation sessions using GOOPI were conducted by the same researcher to ensure consistency and avoid possible influence on the results. This paper only presents the characteristics of GOOPI and how 21-CS results in facilitating students to complete all stages of evaluation. The data collection tool in this study was in the form of a 21st-Century Skills test consisting of Critical Thinking, Collaboration, Communication, and Creativity on the implementation of GOOPI.

6.1. Critical Thinking Test

This Critical Thinking test is based on a test developed by the researcher himself that has been validated by an expert. The test consists of 5 description questions with a reliability coefficient of 0.78 good category. This test question is based on the Critical Thinking indicator and the core competencies of the concept of the structure of the atomic nucleus in accordance with the curriculum. Critical Thinking Indicators used in the research are formulating problems, analyzing arguments, asking, and answering questions, evaluating, and defining (Wechsler, et al., 2018).

6.2. Collaboration Test

This collaboration test is based on a test developed by the researcher himself that has been validated by an expert. The test consists of 5 description questions with a reliability coefficient of 0.70 good category. This test question is based on the Collaboration indicators used in this study, namely the skills to work together, synergize with each other, adapt in various roles and responsibilities, and respect differences of opinion when learning using GOOPI.

6.3. Communication Test

This Communication test is based on a test developed by the researcher himself that has been validated by an expert. This test consists of 5 description questions with a reliability coefficient of 0.68 good category. This test question is based on Communication indicators, namely listening skills, writing skills, oral skills that occur during learning using GOOPI.

6.4. Creativity Test

This Creativity test is based on a test developed by the researcher himself that has been validated by an expert. The test consists of 5 description questions with a reliability coefficient of 0.72 good category. This test question is based on the Creativity indicator and the core competencies of the concept of atomic nucleus structure that are in accordance with the curriculum. Creativity indicators used in the research are asking questions, guessing the causes, guessing the consequences of an event, improving the output (Wechsler, et al., 2018).

7. DataAnalysis

The data analysis of this research was carried out by descriptive analysis by identifying the data outliers that were not good and the extreme data were deleted. Furthermore, the slope of the kurtosis was controlled for each variable, and the data obtained that the data was normally distributed because the value was between -1 and +1. Next, an independent t-test was conducted to determine the difference in the impact of GOOPI on 21-CS. Next, conclusions are drawn from the data obtained as well as recommendations for further research and studies related to online games for learning.

8. Result and Discussion

8.1. GOOPI Characteristics

The GOOPI media used in this study is the result of the development by researchers for approximately 2 years in the multimedia laboratory of the State University of Jakarta, Indonesia. Researchers who are members of Physics Education Research (PER) have conducted a series of studies to examine the working principles of GOOPI (Open Online Physics Instructional Game) as a physics learning medium and can be accessed for free on the following page: <https://goopi.id/>(UC Browser) and has been published (Wibowo, et al., 2020). The characteristics of GOOPI are shown in Figure 2.

Figure 2. GOOPI Opening page <https://goopi.id/>uses UC Browser

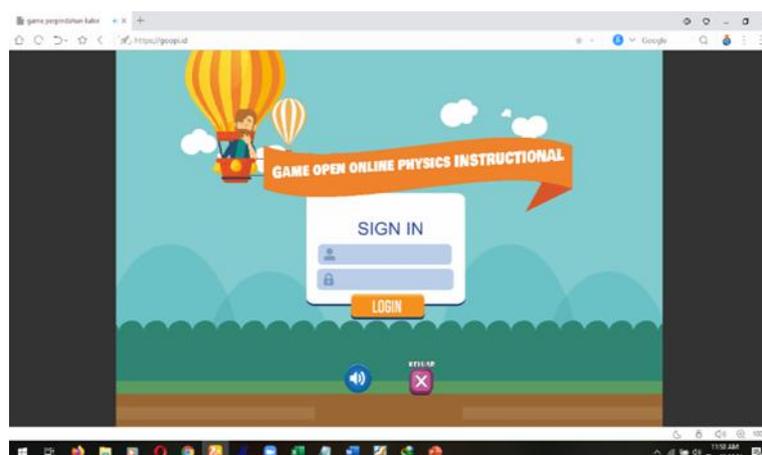


Figure 2 shows the start page of GOOPI, this page can be accessed on the <https://goopi.id/>page to make it more optimal to use UC Browser. To be able to Sing In you can enter a user and password, the user and password are "fisika" and the user is "123". The GOOPI user and password are intentionally given so that students and teachers can optimize it for learning, especially during the Covid-19 pandemic. After entering the user and password, click login to enter. On this home page there is also a sound button if you want to mute the sound. To be able to run GOOP, after logging in, a dashboard will appear as shown in Figure 3.

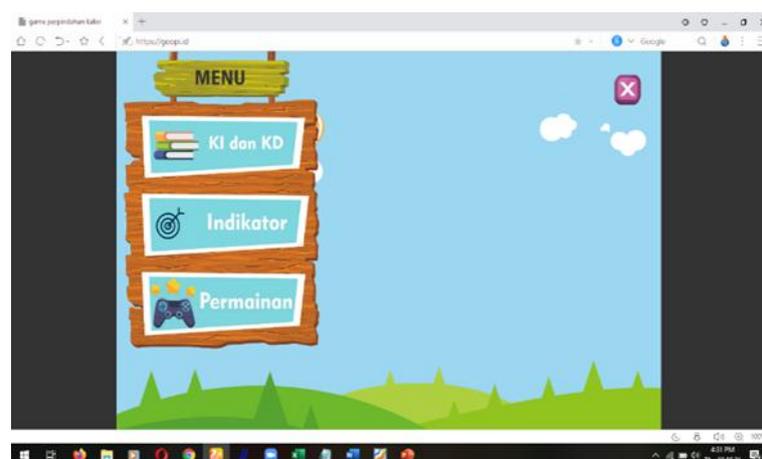


Figure 3. Dashboard after successfully Sign in to GOOPI

Figure 3. Explaining the dashboard after successfully logging in to GOOPI, in this display there are 3 menus, namely KI (Core competence) KD (Basic competence), Learning indicators and Games. On the KI and KD menus, when clicked, the core competencies and basic competencies of GOOPI on the concept of heat transfer will appear. The next menu is the indicator menu, this menu provides information about learning indicators after learning from GOOPI. The last menu is this game which when clicked there are 3 menus Mission, Mission 1, Mission 2 and Mission 3. To clarify what the mission here is as shown in Figure 4.

Figure 4. The Core of GOOPI in the form of Mission 1, Mission 2, and Mission 3

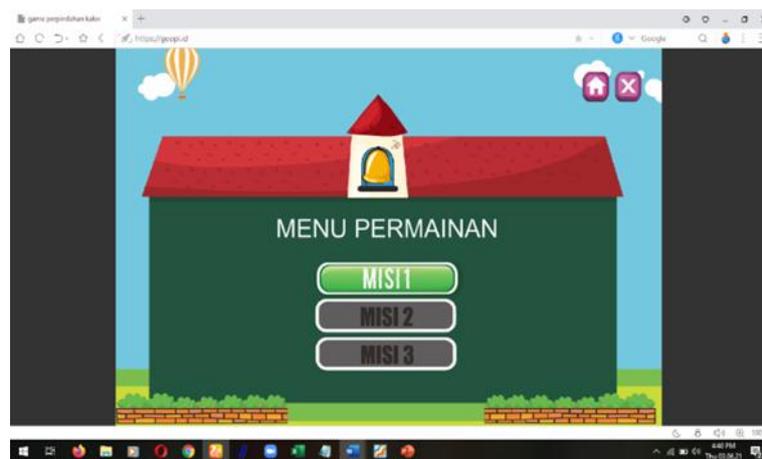


Figure 4 is the core of GOOPI, there are 3 mission menus, Mission 1 is a game play that contains the concept of heat transfer on the topic of conduction. After successfully completing mission 1, the finish button will appear and will go to the Mission 2 menu. Mission 2 contains an online game on the topic of convection, after completing the game on this topic a question will appear that must be answered. If students can answer, the finish button will appear, and they can continue to the Mission 3 menu. Mission 3 This GOOPI menu is the last menu, and this menu contains an online game on the topic of radiation. For more details, menu 1, menu 2 and menu 3 are shown in Figure 5.



Figure 5. Mission 1, Mission 2, and Mission 3 of GOOPI

Based on Figure 5. Information obtained that the GOOPI process in facilitating physics learning the concept of heat transfer. The advantage of GOOPI is that it can visualize microscopic physical material or phenomena. Characteristics of physics learning that is oriented to conception construction is physics learning in which there is a process of building a physics conception from the initial state of not understanding the concept to understanding the concept. Therefore, real steps are needed in the process that can construct knowledge and correct or reconstruct concepts if they are not in accordance with the scientific context. If learning is only through the listening process without doing other things such as taking notes, then the contribution to mastery of the material is only 5%. If it is followed by reading, it will contribute to the mastery of the material by 10% and if learning with audio-visual aids, it will contribute to the mastery of the material by 30%. So that this GOOPI has a positive impact on understanding the concepts and skills of the 21st -Century.

8.2. 21st-Century Skills (21-CS)

The results presented here focus on the usefulness of games for teaching and learning the concept of heat transfer. Therefore, no control group was used in this study. The t-test was conducted to compare the answer choices in the 21-CS test on the concept of heat transfer after learning to use GOOPI. The results of the statistical test showed $t(178) = -15.07$, $p < .001$, this showed a significant difference in the number of correct answers, besides that it showed that students performed significantly better after the implementation of learning using GOOPI. These results show that GOOPI significantly improves 21st-Century Skills (Critical Thinking, Collaboration, Communication, and Creativity).

Table 1. Results of Paired t-test after playing GOOPI in the experimental group

	Post-Test
M	-1,82
SD	1,63
t	-15,07
df	178
Sig. (2-tailed)	.001

Table 1. provides information that the results of the Paired t-test after playing GOOPI in the experimental group on the topic of heat transfer illustrate that GOOPI significantly increases 21st-Century Skills (Critical Thinking, Collaboration, Communication, and Creativity). In addition, most of the students (75.4%) stated that the physics class was challenging, but they could understand it. In addition, 72% of students answered that they enjoy learning science and 78.4% of students have a positive view of science, 59% of students have a different view of motivation to learn apart from applying science in their future career. So, it can be concluded that students' responses to learning with GOOPI show a positive attitude and students look challenged.

The 21st-Century skills carried out in this study are ways of thinking (creativity and innovation; critical thinking, problem solving, and decision making; learning to learn and metacognition), Ways of Working (communication; collaboration and teamwork), Tools for Working (information

literacy), information and communication technology literacy), and Living in the World (life and career; personal and social responsibility). So, the synthesis of 21st-Century Skills (21-CS) is 4C, namely Critical Thinking, Collaboration, Communication, and Creativity as shown in Table 2.

Table 2. Paired t-test results after playing GOOPI from the aspect of 21st-Century Skills

21 st -Century Skills (21-CS)	Items	M	SD	t	df	Sig. (2-tailed)
Critical Thinking	1, 5, 6, 13, 18	-1,42	1,62	-13,35	178	.001
Collaboration	3, 7, 15, 17, 18	-1,47	1,60	-14,56	178	.001
Communication	2, 8, 11, 14, 20	-1,62	1,87	-15,27	178	.001
Creativity	4, 9, 10, 12, 16	-1,68	1,89	-16,19	178	.001

Table 3. provides information that the t test was carried out to compare the answer choices in the critical thinking test on the concept of heat transfer after learning to use GOOPI showing $t(178) = -13.35, p < .001$. this shows that there is a significant difference in the number of correct answers, besides that it shows that students are significantly more critical in thinking after implementing learning using GOOPI. The t-test was conducted to compare the answer choices in the Collaboration test on the concept of heat transfer after learning to use GOOPI showing $t(178) = -14.56, p < .001$. this shows that there is a significant difference in the number of correct answers, besides that it shows that students have significantly more collaboration after implementing learning using GOOPI. The t-test was conducted to compare the answer choices in the Communication test on the concept of heat transfer after learning to use GOOPI showing $t(178) = -15.27, p < .001$. this shows that there is a significant difference in the number of correct answers, besides that it shows that students have significantly more communication after the implementation of learning using GOOPI. Meanwhile, the t-test was conducted to compare the answer choices in the Creativity test on the concept of heat transfer after learning to use GOOPI showing $t(178) = -14.56, p < .001$. this shows that there is a significant difference in the number of correct answers, besides that it shows that students are significantly more creative after implementing learning using GOOPI.

The positive aspect of applying online games for learning is that these games can be accessed and shared with anyone to try this GOOPI in developing an understanding of the concept of heat transfer, topics of conduction, convection, and radiation. However, some students stated that they could not fully express their thoughts because the understanding that was built from this microscopic concept did facilitate thinking skills, but the completion of this game took a relatively long time. A summary of student views is given below:

“... this game contributed significantly to my interest in learning physics concepts, which at first I didn't like physics. Likewise, my understanding of completing mission after mission in this GOOPI trains me to think creatively and critically because to go to the next mission, I must complete a task in the form of a question. This issue is a challenge for me. This causes me to take a relatively long time to think.”

In addition, some expressed negative aspects of GOOPI, namely internet access in areas, especially areas far from urban areas, so that internet signal is very difficult, so this online game is less than

optimal. Many researchers have developed game learning platforms that can be used in education as a means for student engagement in learning activities (Troussas, et al., 2020). Because learning to use online games helps students to be able to participate in learning activities from anywhere and navigate in virtual learning spaces (Tan, et al., 2017). Online or virtual learning can overcome the barriers of distance, time and location, to be able to meet and interact (Chen, et al., 2020). In addition, online games for learning have a positive impact on constructivism concepts and provide experiences to students. Researchers argue that learning using games can facilitate student-centered constructivist learning and make learning more flexible and provide an interesting learning experience (Morschheuser, et al., 2017). Learning games can form conceptual thinking and abstract the real environment. Students demonstrate that learning to use games provides a learning experience in the role of an authentic designer and provides an immersive challenge.

Games are an effective way to increase motivation and attract students to learn (Yeh, et al., 2019) and can be seen as a form of game implemented in learning to improve thinking skills. Games are elements and principles of play in non-game contexts with the aim of increasing student engagement and productivity. Learning games are technologies that dramatically change the location and timing of classroom-based learning. A lot of optimism about the presence of Game Learning in education and for future training because it combines the real world with additional information in an interactive way. Game learning makes the educational environment more productive, interesting, and interactive, challenging students to learn (Tan, et al., 2017). In addition, Game Learning can be focused on simplicity and ease of use to provide benefits and an independent learning experience.

The use of Game learning allows users to learn microscopic physics concepts and communication interfaces in one dimension based on text into a 3D environment colorful, and immersive (Chen, et al., 2020). Students enjoy learning in this GOOPI user because students like to use the visual world in 3D space and socialize. This online game encourages interaction between students in connecting people from various parts of the world with 3D virtual technology (Cahyana, et al., 2017). Overall, online games provide a virtual environment to create a shared experience for students and teachers to work collaboratively together and demonstrate instruction. However, there are several barriers and challenges to the adoption of online games for learning. These obstacles include (1) lack of explanation in learning because it only uses games; (2) students do not focus on learning because they always hold their cellphones; (3) lack of interaction between students and teachers; (4) internet signal interference.

Online games can be used by teachers to develop students' higher order thinking skills that encourage learning by design that requires skills such as analysis, evaluation, and creation. The efficiency and effectiveness of online games in education and training has been proven in almost all K-12 domains and higher education curricula such as mathematics, geometry, physics, science physics, biology, chemistry, astronomy, history, geo-engineering robotics or non-robotics and other subjects. other academic activities that provide attraction, stimulation, and excitement.

9. Conclusion

Media and technology are used as tools for visualizing the nature of the teaching and learning process to support educational goals such as skills for finding and assessing information, collaboration, communication, and problem solving. Efforts to empower teacher performance in

improving online learning need to be facilitated with online game media that can be accessed for free and can be accessed from anywhere. This is so that, during the pandemic, students do not feel bored and lack interest, motivation, and persistence in learning remotely. With this GOOPI media, it can support online learning which is designed in line with the changes in the industrial revolution 4.0, it can make students more motivated in online learning and learning. GOOPI is an online game learning media on the concept of heat transfer that can challenge students to learn because there are missions that must be completed. In addition, GOOPI is equipped with simulations on microscopic concepts so that they can improve students' understanding of concepts and are easily accessible to students and teachers. The recommendation from students using GOOPI is that the teaching of physics assisted by GOOPI makes a positive contribution to 21st-century achievements and skills. GOOPI technology is used to teach the concept of heat transfer, which can be adopted in other physics concepts or other subjects where there are unobservable concepts. The study was conducted with students aged 15 to 17 so that a similar study could be conducted with students in different classes.

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