Virtual Laboratory-Based Game Application: The Quality and Its Effects Towards Students' Motivation and Self-Regulated Learning

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Abstract—Considering that students have a lot of experiences using mobile applications in their daily life, teacher should engage mobile application as learning media, thus the student are more motivated to learn independently. As a consequence, the teachers should implement existing mobile learning in the learning process and it is even better if they can develop it themselves. Besides, developing mobile learning is being heavy burden for a teacher as they still lack of skills to design and to develop mobile learning. Therefore, we aimed to explore the quality of Amazing Science application as mobile learning incorporated with a virtual laboratory based game application and to investigate its effect on students' motivation and self-regulated learning. This research involved 5 sciences teachers and 50 students from five secondary schools in Yogyakarta, Indonesia. The research data were collected through online questionnaires consisting of three instruments, namely; viz product quality questionnaire for product validation, motivation questionnaires and self-regulated questionnaires for product implementation. Product validation data are quality data in the form of categories, so they are converted to data score using the Likert scale. Meanwhile, implementation data consisting of motivation and self-regulated learning data were analyzed with a sample paired t-test to discover the effect of product implementation towards motivation and self-regulated learning. The result revealed that Amazing Science application has a good quality according to the reviewers and students through a preliminary test and limited trial. Moreover, there are significant differences in both students' motivation and self-regulated learning before and after the implementation of Amazing Science. However, there is no significant correlation between students' motivation and self-regulated learning. From the findings, it can suggest that Amazing Science should be implemented by combining with the cooperative learning model, so others' skills can be improved. Besides, it can rebuild on another learning material or subject.

Keywords—game application, mobile learning, motivation, self-regulated learning, virtual laboratory

1 Introduction

The emergence of Education 4.0 certainly caused the question of how to develop learning media by the needs of the digital world. Learning media has an important role in forming a vital instructive movement to adapt to Education 4.0. The advances that have developed exponentially and progressed rapidly have an effect on two of the foremost imperative subjects for students in school today are technological and digital literacy. Following the development of the digital world, at the same time, students surely have been reacting and growing up in the fact of the learning process in a highly digital world [1]. The undenied condition is that both teacher and student are finding it difficult to adjust and personalize learning process and strategy.

Recently, many new ideas to create mobile learning appeared to facilitate students as a learning media in Education 4.0 era [2-5]. Over the last recent years, mobile learning in educational utilization is predicted as an interactive learning media that supports the learning process and brings new technology into the classroom [3]. One of the effective keys to enhance learning outcome is to make the dynamic and proactive learning and teaching environment by utilizing technology in the class [6]. Hence, various learning technology innovations are carried out to virtualize the learning environment [7]. Utilization of learning tools that supported the digital era ultimately can improve students' achievement [8], students' overall learning [9], students' motivation [10], and students' self-regulated learning [11]. Therefore, mobile learning has been noted as potential tool for pedagogic use [12]. As a consequence, the teachers have a great opportunity to implement mobile learning in the learning process even better if they can develop it.

However, the challenges to reach the goal are unavoidable. The survey that has been conducted in many secondary schools in Yogyakarta reported that many teachers still lack of skills to design and to develop mobile learning applications. The training to develop mobile learning for teachers is still rarely held and if any, it is only optional. Therefore, many teachers still choose to do conventional learning instead of using educational technology. The technological learning tool that they applied mostly in science class are more focused on providing illustrations using PowerPoint slides and playing learning videos.

Despite teachers' incapability to develop mobile learning apps, the teachers must be aware of the fact that this tool can motivate teachers to promote teaching and learning in a modern educational environment [2]. Moreover, one of the benefits of mobile learning in education is eliminating technological infrastructure problems, such as, information access limitation. This technology can also be used as an inexpensive learning tool; providing adorable features like a images, sounds, and videos; offering technical support to teacher during urgent online learning; and supporting continuous and situated learning [13,14]. The implementation of mobile learning is expected to collaborate with appropriate learning strategies and methods to achieve better outcomes. Therefore, such an interactive learning tool has a potential opportunity to be implemented in blended learning [15].

In line with the fact that mobile learning is declared as a beneficial learning tool, its features are not only limited to the learning material delivery, but also offers the

opportunity for students to explore more learning activities such as in the classroom. The application that may be included in mobile learning are augmented reality (AR) and virtual laboratory. A virtual laboratory can facilitate students to interact with the virtual object similar to those in everyday life. This technology leads the easier way for students to simulate laboratory activities without serious risk. This favorable circumstance allows students to gain experience in terms of being a meaningful learning [16].

In the covid-19 pandemic era, learning activities in schools and universities around the world have been suspended without clear indicators for the 2020-2021 school year [17-20]. This was done to prevent the spread of covid-19 in schools and universities. Therefore, one of the steps taken by the government to prevent the cessation of teaching and learning process switched to online or distance learning. Online learning is one of the best alternatives learning in covid-19 pandemic. Although students cannot meet directly with the teacher, interactions can still occur by conducting online learning process. Ideal online learning activities can be done by choosing the suitable learning media according to the characteristics of the learning content. Virtual learning applications utilized to perform online learning are Zoom, Google Meet, Webex, and other working simulation application in laboratory such as practicum videos and virtual labs. By using these applications, it is expected that the learning process can run smoothly, so students can still hone their abilities, both cognitive and practical abilities and skills. Nevertheless, Can & Bardakci [13] revealed that the interaction between students and teachers during online learning was generally inadequate because there was no direct socialization and not all schools have adequate technological equipment. Hence, school should facilitate technological development and establishment of digital learning culture in the school and learning, besides teachers and students should be familiar with information, tools, and frameworks to adapt to online [13, 18, 21]. Thus, the implementation of technology in learning process must be done carefully by choosing the proper technology according to the characteristics of learning materials and student learning style [22].

Several prior studies discussed about re-imagining of an existing experiment in the laboratory into a virtual world. Laboratory activities required expensive cost and consume more time, thus they revealed that virtual laboratory is one of the promising learning tools[23,24]. Supporting these findings, many obstacles of science education can be reduced by virtual laboratory, especially the unavailability of equipment and materials for experiments in the laboratory [25]. A virtual laboratory can be used in many science subjects, such as the topic of electrical conductivity in the secondary school level. It can also provide convenient hands-on practical experience for students virtually [26].

Seeing the importance of both mobile learning and virtual laboratory, we aim to continue the previous project on mobile learning incorporated with virtual laboratory development, namely Amazing Science. The prior research revealed that Amazing Science was feasible as a science learning tool according to the experts [27]. In this research, we focused on validating the product and conducting a pilot test for students. Moreover, we also conducted the implementation stage and its effect on students' motivation and self-regulated learning. Supporting this project, appropriately- designed

mobile learning applications has a huge potential to be a successful platform to boost self-regulated learning [28]. Besides, students' motivation will also increase through mobile learning applications and virtual laboratory [29,30].

According to these backgrounds of research, we have identified crucial matters that teaching electrical conductivity rarely bringing mobile learning in the science classroom as well as the virtual laboratory as follows. In addressing this scope of problem, we aimed to explore the quality of Amazing Science application as mobile learning incorporated with a virtual laboratory based game application and to investigate the effect of the implementation of Amazing Science on students' motivation and self-regulated learning.

2 Method

2.1 Research design

The study was the follow-up research that developed mobile learning application incorporated with virtual laboratory-based game application. The previous research has revealed that Amazing Science was successfully developed through the ADDIE model and was suitable for used in science classrooms according to experts' validation [27]. The current study focuses on the product validation by the teachers and limited trials by students. After being declared feasible, Amazing Science was implemented on students to investigate its effects on students' motivation and self-regulated learning. Therefore, this study was mixed-method research that involved collecting and analyzing both qualitative and quantitative data. The research participants, procedures, product design, instruments, and data analysis are explaiend as follows.

2.2 Participants

The present study involved 5 science teachers and 50 students from five secondary schools in Yogyakarta, Indonesia, that was selected by using the random sampling technique. The limitation of sample selection was caused by the health protocol due to the pandemic and also schools' regulations where schools only allow a limited number students who to attend school activities, so we selected ten students from each school. The science teachers were appointed as reviewers, and they were requested for preliminary testing to evaluate and to assess the quality of Amazing Science. Meanwhile, the students were asked to do some trials to operate the application in the learning process and they were also asked to assess the quality of Amazing Science application. In addition, the students were involved in the product implementation stage to investigate its effect on students' motivation and self-regulated learning.

2.3 Research procedures

First of all, this study aimed to describe the quality of Amazing Science by referring to the assessment from the science teachers. The product was validated by the teachers

to attain the level of feasible learning media. The revision was done right after the product was validated according to the validation sheet. The product then was introduced to students in the limited trial process. In this process, the students were allowed to give feedbacks and recommendations through the given suggestion sheet. Then, the product was revised to fulfill the user's convenience. After the final revision was made, Amazing Science was ready to be implemented in the science classroom as a learning media.

The study did not include experimental and control groups; instead, a pre-test and a post-test were applied to the students. The implementation stage using Amazing Science was conducted by blended learning for 3 meetings. The first meeting was held in a face-to-face situation, while the next meeting was conducted through online classes. In the first meeting, the students were provided the instruction of media operation and were asked to fill out the motivation and self-regulated questionnaire as the pretest. The next meeting was held through online learning using meeting application such as Zoom and integrated with Amazing Science. İn the last meeting, the same motivation and self-regulated questionnaire were administered again, as a post-test. Each questionnaire was provided on the online form. The learning process was conducted over three weeks in October 2020, lasting for 90 minutes each meeting.

2.4 Research ınstruments

Product quality questionnaire. The product quality questionnaire was used to assess product quality describing on teaching aspect, learning material aspect, audiovisual aspect, and software engineering aspect. It is developed according to component of teaching materials includes aspects of the feasibility of content, language, presentation, and graphics [31]. It has been validated by the two experts to prove the content validity and has been proven valid according to content validity.

The product quality questionnaire was designed on a five-point Likert scale: *very good* (5), *good* (4), *adequate* (3), *poor* (2), and *very poor* (1). It consists of two types of product quality questionnaires i.e. product quality questionnaires for teachers and students. The difference between these types is the number of aspects contained in the questionnaire. The product quality instrument for teachers contains all aspects of product quality consisted of 34 statements that assessed four indicators as follows: teaching aspects, learning material, audio and visual, and software engineering. Meanwhile, the product quality instrument for students only contain the learning material aspect and the media operation aspect consisted of 15 statements. At the end of each questionnaire, a suggestion sheet was adimnnistered as supporting material for the improvement of Amazing Science.

Motivation questionnaire. A motivation questionnaire was initially used to collect the data during the product implementation process. The implementation was proposed to investigate its effect on students' learning motivation. The instrument namely the Motivated Strategies for Learning Questionnaire (MLSQ) adopted from [32]. A total of 56 items were proposed to explore three distinct motivational factors: self-efficacy ($\alpha = .89$), intrinsic value ($\alpha = .87$), and test anxiety ($\alpha = .75$). Students were instructed to

respond to the items on a 4-point Likert scale from 4 = *very true of me* till 1 = *not at all true of me*. Among a total of 56 items, there are 6 negative expressions.

Self-regulated questionnaire. Again, the students had also to respond to the self-regulated questionnaire during the product implementation process. This research adopted the questionnaire from [33] which comprised of highly reliable 22 items, included 4 negative expressions (α = .894). The questionnaire was performed on a 4-point Likert scale from *4 = very true of me* till *1 = not at all true of me.* Certainly, the negative expressions have the opposite value with the positives. This questionnaire insisted to explore students' actions within self-regulated learning in which they do performance consistently according to their reporting.

2.5 The design of amazing science

The Amazing Science is mobile learning application incorporated with the virtual laboratory that can be played individually. It is mobile application that combine game, virtual lab and learning media for science content in secondary school. It has been developed in the previous study [27]. It can be installed both in android and i-phone. It has three levels included learning material, virtual laboratory, and evaluation. Figure 1 shows the interface of the homepage screen of Amazing Science. The grey buttons on the homepage mean that the level not yet played by the user. The application was designed related to the learning topic of electricity. It can attract students to learn electricity in a pleasurable way.

Fig. 1. The interface of the amazing science homepage screen

The first level provides many images and videos that can help the students to understand the learning material. Meanwhile, Figure 2 display the interface of fame mission at the first level. The students should complete the mission at the first level to access learning materials. Besides, at this level, we also provide questions about daily phenomenon that students have to answer. These questions effectively relate knowledge to everyday occurrence, hence they can promote student ideas [34]. To answer the questions, the students are allowed to discuss with their friends. The second level provide virtual laboratory where the students can do experiments virtually.They can conduct an experiment about electrical conductivity like they were in the laboratory. Then, Figure 3 displays the interface of the virtual laboratory in Amazing Science. We

illustrate the couple of hands instead of the avatar as a user movement. At the beginning of first level and second level, the students have to complete the game mission in order to access the learning materals in first level and virtual laboratory in second level. The last level is evaluation level for assessing students in 15 questions about the learning material and experiment that they have conducted in the virtual laboratory.

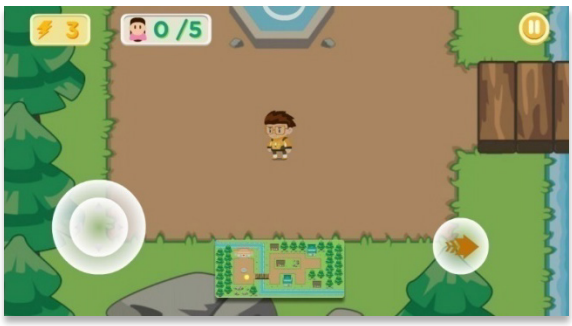

Fig. 2. The interface of fame mission in first level

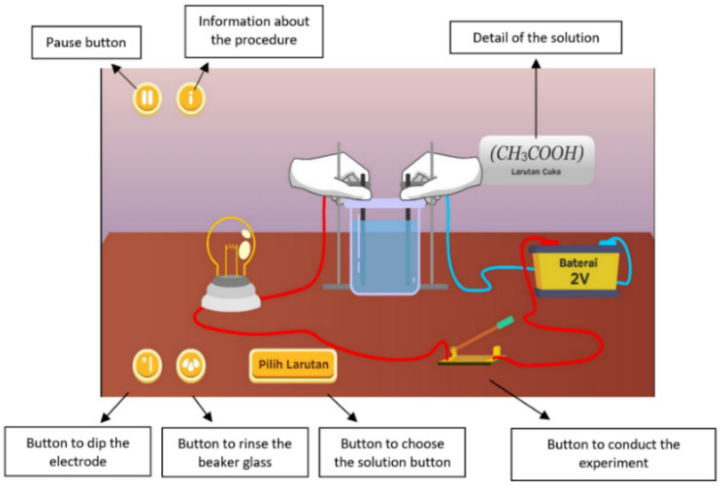

Fig. 3. The interface of virtual laboratory in amazing science

2.6 Data analysis

The data collected through product quality assessment were analyzed using ideal assessment criteria while the data collected through the product implementation were analyzed using a sample paired t-test. The product quality score data were in the form of categorical data which were then converted into a score using a Likert scale. The data were tabulated in the form of scores, then the average score of the results of the assessment of the learning media were calculated. The determination of qualitative criteria for mobile learning can be seen in Table 1. Meanwhile, the data from the

suggestion sheet is considered as qualitative data that brings the improvement for the product.

Table 1. Ideal assessment criteria

No.	Range of Score (i)	Category
1.	$X_i + 1.8SB_i < \overline{X}$	Very Good
2.	$X_i + .6SB_i < \overline{X} \leq X_i + 1.8SB_i$	Good
3.	$X_i - .6SB_i < \overline{X} \leq X_i + .6SB_i$	Adequate
4.	$X_i - 1.8SB_i < \overline{X} \leq X_i - .6SB_i$	Poor
5.	$\overline{X} \leq X_i - 1.8SB_i$	Very Poor

The statistical software SPSS version 23 was used to analyze the sample paired t-test due to the sample size is less than equal to 30. It is used to find out whether there is an effect of product implementation towards students' motivation and self-regulated learning. The sample paired t-test was set an alpha level of 0.05 to determine any differences. Pearson correlation was performed in order to investigate the degree of strength of the relationship between these variables.

3 Results

3.1 The quality of amazing science

Five reviewers consisting of teachers from various secondary schools in Yogyakarta have been involved in this study. The reviewers were requested to assess the quality of media according to product quality instruments. The distributed questionnaire consists of 34 statements regarding the components of media quality which includes teaching aspects, learning materials, and software engineering. The results of the Amazing Science product quality assessment can be seen in Table 2. Based on the calculation results, the overall product quality average score is 142.2. When compared to the ideal assessment criteria table, the average score obtained is in the range $115.2 \leq \bar{X} \leq 153.6$, which is categorized as *good quality.* Besides being able to be seen as a whole, each component is also assessed and calculated based on Table 1. The table of ideal assessment criteria for all assessed aspects is shown in Table 3. The calculation results for each component also show that the quality is in a good category.

The calculation of the assessment criteria, in the same way as Table 3, was used to determine the criteria for each component that was assessed by the reviewer. The teaching aspects and software engineering components have the same calculation range because each of them has five indicators that must be assessed by reviewers. The calculation results revealed that the two components were in the range $18 \leq \bar{X} \leq 24$, so they can be classified into the good category. The learning material component has nine indicators that must be assessed by the reviewer and obtains an average score of 40. The average score is in the range of category $32 \leq \bar{X} \leq 43$, thus it classifies to the good category. Meanwhile, the audio and visual components also have a good category like

other components because its average score is in the range $47 \leq \bar{X} \leq 62$ based on the calculation.

Table 2. The product quality data based on preliminary tryout by reviewers

Reviewer	Components				Total
	Teaching aspects	***Learning material***	***Audio and visual***	***Software engineering***	
A	24	42	59	25	150
B	18	41	60	24	143
C	21	39	56	24	140
D	24	40	58	22	144
E	25	38	53	18	134
Total	112	200	286	113	711
Average	22.4	40	57.2	22.6	142.2
Category	Good	Good	Good	Good	Good

Table 3. The calculation of interval range on a preliminary tryout for all components

No.	Range of Score (i)	Category
1.	$153.6 < \bar{X}$	Very Good
2.	$115.2 < \bar{X} < 153.6$	Good
3.	$76.8 < \bar{X} < 115.2$	Adequate
4.	$38.4 < \bar{X} < 76.8$	Poor
5.	$\bar{X} < 38.4$	Very Poor

In addition to product quality assessment conducted by reviewers, a limited trial was also performed by 50 students to determine students responses toward the Amazing Science. The components that were assessed on the questionnaire for students were fewer than the product quality questionnaire for teachers, namely, there were only two components i.e. learning materials and media operations. Table 1 is still used as a reference in calculating data from limited trial results to obtain product quality category. Table 4 indicates that the limited trial data gave the desired results, in terms of Amazing Science was classified into the good category.

Table 4. The product quality data based on limited trial by students

	Total	Average	Category
Learning material	1160	23.2	Good
Media operation	2080	41.6	Good
Total	3240		
Average	64.8		
Category	Good		

Meanwhile, the learning material component has 5 indicators, while media operations have 10 indicators that must be assessed by students. The average score

obtained for the learning material component was in a good category because it is in the range of $18 \leq \bar{X} \leq 24$. The same results were also revealed for the media operation component because the average score is in the range of $32 \leq \bar{X} \leq 4$, thus was clasiffied a good category. Therefore, all components tested on students obtained a good category with an average score of 64.8, which was in the range of $50.4 \leq \bar{X} \leq 67.2$ as ilustrated in Table 5.

Table 5. The calculation of Interval range on limited trial for all components

No.	Range of Score (i)	Category
1.	$67.2 < \bar{X}$	Very Good
2.	$50.4 < \bar{X} < 67.2$	Good
3.	$33.6 < \bar{X} < 50.4$	Adequate
4.	$16.8 < \bar{X} < 33.6$	Poor
5.	$\bar{X} < 16.8$	Very Poor

3.2 Implementation stage of amazing science

The product was proven to have good quality based on experts' judgment in the previous studies and was categorized as a good learning media as in this study by the reviewers and the students. Hence, Amazing Science is suitable to be used as a learning media in the classroom. Therefore, this research was continued to the implementation stage of Amazing Science in science learning to discover its effect on students' motivation and self-regulated learning. Students are given the questionnaires of motivation and self-regulated learning twice, which were before and after implementation stage. The gain score obtained was used for sample paired t-test analysis using SPSS 23. Table 6 illustrate the results obtained in the sample paired t-test analysis for the student's learning motivation variables

Table 6. Sample paired t-test output for motivation data

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	*Upper*			
Pair 1	pretest-posttest	-1.99E1	9.76	1.38	-22.67	-17.13	-14.42	49	0.000

The null hypothesis in this part was that there was no significant difference in motivation before and after the treatment. As presented in Table 6, the obtained sig value is 0.000<0.05 indicating that the null hypothesis was rejected. These results can be interprated that there was a statistically significant difference in students' motivation before and after learning using Amazing Science. Again, the sample paired t-test for the self-regulated learning variable also presented the same results as seen in Table 7. The null hypothesis in this part was that there was no significant difference in self-regulated learning before and after the implementation stage. The sig value < 0.05

indicated that the null hypothesis was rejected, so it can be interpreted that there was statistically significant differences in self-regulated learning before and after implementation stage using the Amazing Science.

Table 7. Sample paired t-test output for self-regulated data

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	Df	Sig. (2-tailed)
					Lower	*Upper*			
Pair 1	pretest-posttest	-9.20	2.14	0.30	-9.81	-8.59	-30.43	49	0.00

To explore more about the correlation between the two variables, Pearson correlation analysis was conducted. Table 8 was the output from the Pearson correlation analysis using SPSS 23. The small value of r obtained and the negative result of -0.178 indicated that there was no relationship formed between the two variables. This interpretation is reinforced by a sig value > 0.05 indicating that the null hypothesis was accepted. Therefore, this study revealed that there was no significant correlation between students' motivation and self-regulated learning.

Table 8. The Pearson correlation output

		Motivation	Self-regulated learning
Motivation	Pearson Correlation	1	-0.178
	Sig. (2-tailed)		0.217
	N	50	50
Self-regulated learning	Pearson Correlation	-0.178	1
	Sig. (2-tailed)	0.217	
	N	50	50

4 Discussion

4.1 Quality of amazing science

The Amazing Science has been successfully developed in the previous study by adapting the ADDIE model and using Adobe Animate CC 2017 for software development. The product is designed for students to be able to play, to learn, and to practice about electrical conductivity. The Amazing Science is divided into 3 levels. The first level consists of learning materials, the second level is utilized as a virtual laboratory, and the last level is designed for evaluation. At the beginning of each level, the user must complete the game mission to access the learning materials on first level and to perform the virtual laboratory on second level, while the last level is a combination of game and evaluation where users are asked to answer a total of 15

questions. In this study, the researcher wqw more focused on testing the feasibility of the product by reviewers and limited trials by secondary school students.

The learning material components including eight indicators that were assessed by reviewers were clarity of learning material, the coherency of learning material, appropriate question formulas, interesting learning material delivery, appropriate language, ambiguity, appropriate example, and correct feedback. The learning materials are composed by referring to the indicators and learning objectives that will be achieved by students at the end of learning process. At the first level, the content materials are composed in an attractive way by providing abundant illustrations in the form of pictures, animations, and videos to keep the students motivated to learn. This is proven by the results of the calculation of the score during the limited trial stage.

Students also provided a fairly high score. As illustrated in Table 4, the learning components assessed during the limited trial stage indicated results in the good category. These results also indicate that students can understand electrical conductivity subject well through Amazing Science. The collaboration between the presentation of learning materials and the way of materials delivery tends to greatly influence students' interest and motivation in studying these subjects. İf the content materials in the learning media are presented in attractive and interesting ways, the student will be interested to learn. Moreover, if the content delivery is made interactively, the students will not get bored quickly. This is potential in the sense that it can provide the way for students to learn in the best environment, which may enhance their overall performance [35]. Also, it allows students to reach the course effectively at anytime and anywhere [36].

The good quality of the learning materials supported by the preparation of teaching component can enhance students' attention in participating in learning [37]. The learning material indicators should be adjusted to the learning content, learning indicators, examples and illustrations that support the learning content, and appropriate feedback. These indicators are an inseparable unit because they are interrelated and are the main requirement in composing good learning material. As ilustrated in Table 2, the material compiled in Amazing Science is classified in a good category. It indicates that the products has fulfill the requirements for the learning material preparation according to the standards.

Meanwhile, audiovisual is a component that should not be underestimated in the development of mobile learning because it can stimulate the sense of multiple impressions through eye and ear [38]. This component can satisfy the user while operating the Amazing Science and influence the level of user interest. Every action in this application is accompanied by a supportive audio, especially at the game level and virtual laboratory. However, the audio in the las level or evaluation level is designed not to be highlighted in order to students can focus on answering questions.

The other crucial component in developing mobile learning is software engineering. The software engineering indicators component that assessed by the reviewer consist of flexibility, clarity of the direction, creativity and innovation, capability, and opportunity in advanced science and technology. Considering that the main purpose of developing a virtual laboratory is that students should feel like they are working in a real laboratory, more attention is paid to software engineering. Students required

learning media with advanced features that are similar to the real world for supporting online based learning [7].

The mobile learning incorporated with virtual laboratory, Amazing Science, has a good quality according to the reviewers and students through a limited trial. Therefore, it highly recommends being implemented in the science classroom. Due to its potential, Amazing Science should be applied by combining it with a collaborative learning model in order to improve other students' skills, like science process skills. The combination of collaborative learning with potential learning media like mobile learning can enhance quality of learning process and learning outcomes [39-42]. This implementation enables students to reach meaningful learning.

4.2 Implementation of amazing science

The majority of students' activity in the utilization of mobile phones in their daily life have brought the crucial reason for this study. Since the mobile phone is the primary device which is used during this digital era, particularly in the Covid-19 pandemic era, the learning process is designed to be personalized by this condition. It 'forces' schools to set out on digital learning with an online learning method to settle the learning process continuity [43]. Digital learning during the pandemic can be implemented in various ways using various applications as learning media [44]. Amazing Science can be suitable learning media for students because it makes the learning process more flexible and students can experience practice without attending the laboratory. Because the product quality based on the result of the development stage is proven to be in a good category, Amazing Science is feasible to be implemented in investigating its effectiveness.

The limitation of sample selection was caused by the health protocol due to the pandemic and also schools' regulations where schools only allow a limited number students who to attend school activities. The researcher put an effort to guide how to operate the product and the contents of the questionnaire which would have made them choose the rational choice. Besides, the researcher helped and assisted students in exploring the learning material engaging with experience in daily life. Therefore, the first meeting of this study was conducted in the form of face-to-face meeting, while the rest of the meetings through online learning. The first meeting was begun by exploring the previous students' motivation and self-regulated learning in the science classroom by filling the questionnaire. A total of 78 questions which were made up of 22 items of motivation questionnaire and 56 items of the self-regulated questionnaire was administered to students.

The reason for holding 3 meetings in the science classroom bringing the Amazing Science was to establish the gain of students' motivation and self-regulated learning based on prior and after the implementation. During the learning process students gave a welcoming response and participated in science learning enthusiastically. This positive atmosphere indicates that students deal with no difficulties and have great motivation in learning electrical conductivity that is considered difficult material. Mobile learning can empower students to become motivated learners, attract students' interest in learning, and support self-managed learning[1,45]. Moreover, virtual

laboratory was ultimately able to create educational experiences through interaction and illusions [46]. This circumstance ensures students to encourage with the virtual learning education.

In the last meeting, students were asked to fill the same questionnaire to explore the differences between students' motivation and self-regulated learning before and after the treatment. Evidence in Tables 6 and 7 imply that there are significant differences in both students' motivation and self-regulated learning before and after the treatment. Hence, Amazing Science demonstrates a positive impact on student's motivation and self-regulated learning supports the opportunity for students to take more responsibility for their own learning, so it can enhance students' productivity [28,45]. This desired result can be caused by the accessible design of the learning material that connects student concerns, so the desire for understanding the concept can increase [34].

Further analysis is purposed to investigate the correlation between the two variables. The Pearson correlation displayed in Table 8 briefly shows that there is no significant correlation between students' motivation and self-regulated learning. Moreover, the Pearson correlation value (r) has a negative result. A negative correlation means the inverse relationship whereas one variable increases and the other decreases [47]. Based on this result, motivation has a very weak opposite correlation with self-regulated learning. It is caused by the pandemic era in which students lack of guidance from the teacher. No one particularly observes the way of how students learn the material. Students are more likely to choose to do other activities than to study. Teacher supervision is needed during the class in choosing suitable media for online learning. Thus, teachers can observe whether the students follow the lesson or not. On the contrary, motivation was the essential factor to increase the students' self-regulated learning because it mainly related to their needs and interest [48].

To support the findings, the research conducted by [49,50] reported that classroom teaching guidance is urgently needed because it can emphasize students' motivation and self-regulated learning. Rationally, teacher guidance can be categorized as the external motivation. Concerning students' self-regulated learning, students' learning strategies promise to take important factors of self-regulated learning [51]. Having the proper strategies can help the students to manage the learning process. In the virtual environment students take the main role as self-directed learners [52]. This situation surely reduces the teacher's role as an instructor. Hence, according to the findings, mobile learning alone is more capable to improve students' motivation and self-regulated learning, but there are unexpected factors that can closely influence the relationship between the two variables, such as lacking of teachers' monitor and supervision in this pandemic era.

Finally, since the research result of product development is categorized as good quality, the researcher promotes the Amazing Science as a suitable learning medium for teacher and students to support teaching and learning in the science classroom. Future research is suggested to consider another variable to find out the effectiveness of Amazing Science. Furthermore, the variables can be modified with a suitable learning model. The limited number of total participants in the implementation stage is the deficiency of this result, so it is suggested that further research increase its number.

5 Conclusion and recommendations

Based on the result, we can conclude that the virtual lab incorporated with mobile game-based learning product has a good quality according to the reviewers and students' assessment based on the criteria of teaching materials including teaching aspect, learning material aspect, audiovisual aspect, and software engineering aspect. Thus, this application can be utilized as learning media to help students to understand the learning materials, especially in electrical conductivity subject. Moreover, its implementation has significantly influenced the students' motivation and students' self-regulated learning, but there is no significant correlation between those variables.

Students can learn independently and do experiments virtually using this aplication. As learning media, it can support the distance learning policy that is currently being implemented due to the covid-19 pandemic. Based on the development of this application, we hope it can inspire the teachers or the other researchers to develop innovative learning media or it can rebuild on another learning material or subject. Due to its potential, it is necessary to apply Amazing Science with a collaborative learning model to improve other students' skills.

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