Learning Metabolic System Using Phet Simulation to Improve Student Motivation

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Abstract. *Purpose*: This paper investigated the implementation of PhET simulation on student motivation in learning the metabolism system. *Methodology*: The method used in this research was a quasy experiment research design. Quasy experiment is a single treatment design (one shot case study) which is the simplest design. A group of subjects were given treatment (X), then observations were made (Y). In this design, a group of research subjects received treatment, then the variables were measured to be observed (Latipun, 2004). One shot case study, which is an experiment carried out without a comparison group and also without an initial test (Arikunto, 2005). The qualitative data was detected through motivation rubric and questionnaire. *Results*: The result showed that the students who learn the metabolic system with PhET simulation have higher both improvement in conceptual understanding and motivation than without those who learn metabolic system PhET simulation as teaching media. *Applications/Originality/Value*: PhET simulation was only treated in the experiment group. Therefore, it resulted in different perspectives between before and afrter the experiment group about PhET simulation. As the result, they were fairly motivated in learning eating and excersise topic.
Keywords: Learning metabolisme system, phet simulation, student's motivation.

INTRODUCTION

Upon learning from previous influenza epidemic studies (Cauchemez et al., 2008, 2009), school closures were also introduced to help try to contain the virus. School closure is a non-pharmaceutical prevention program designed to reduce the number of cases and reduce the spread of the virus (Abdollahi et al., 2020; Cauchemez et al., 2008, 2009; Earn, 2012; Esposito & Principi, 2020; Jackson et al., 2016; Viner et al., 2020). During the outbreak of COVID-19, policies on school closures in different countries occurred in rapid and massive succession (Rahiem, 2021). In the first week of April 202, the UN Educational, Scientific, and Cultural Organization reported that 195 countries had enforced national school closures, affecting almost 91.3 percent of the world's student population, or 1.598.099.000 affected learners (UNESCO, 2020).

Indonesia has done a lot of progress in the new curriculum and during change of curriculum, the purpose is to improve the quality of the learning process and the existing of learning design in the school area. Therefore, the curriculum in Indonesia will need society. The 2013 curriculum is expected to improve the best quality of education in Indonesia. The junior high school education has an important role in preparing students to innovate in the global era of the Fourth Industrial Revolution (4.0). this level of school must be able to provide students who have the expertise to compete and excel. To be succeeded in the global era of the Fourth Industrial Revolution (4.0), students need skills that support them such as creativity, critical thinking, problem solving, innovation, literacy, communication, responsibility and collaboration (Griffin, P. and Care, 2015).

The facts of education in Indonesia that students have not maximized their ability to think scientifically. This is reinforced by a preliminary study on the development of science learning models and tools specifically designed to increase students' scientific creativity due to the low scientific creativity skills of junior high school students in learning science and the limitations of teachers to deliver material (Astutik, S., Nur, M., and Susantini, 2015). Students need an appropriate learning model, one of which is the collaborative creativity learning model (CCL) as a solution to increasing students 'scientific creativity in science learning and to increase students' scientific creativity in science learning. (Astutik, 2018).

Technological developments in communication include two rapidly growing technologies, namely mobile phones or hand-phones and computers with the Internet network. Global demands require education to adapt technological developments in improving the quality of education especially the adjustment of the use of learning media such as the use of computer media with the Internet network. The use of computer multimedia can be used as an alternative to improve students' science process skills (Siahaan P, Suryani A, Kaniawati I, 2017).

Students need a worksheet to support the use of the media. So, that the competence to be achieved in a learning can be fulfilled. The student's worksheet should contain the title, basic competencies, completion time, tools and materials used, brief informations, steps of activities, tasks to be performed, and reports to be worked on. A worksheet is a tool used in learning to help learners in doing activities in sequence (Rahmi R, 2014). The student's Worksheet can also be a guide for cognitive training or a guide to develope learning in the form of a practicum or demonstration guide (Sasanti M, 2017). It is very important because students seek information and conclusions in groups through this student's worksheet (Misbah M, Dewantara D, 2018). The student's Worksheet based guided inquiry allows students to apply the learned concepts and to solve problems based on science process skills (SPS) (Rahmi R, 2014).

The student's Worksheet is also useful in improving process skills, scientific attitudes and learning interests (Sintia R, 2014). This is consistent with Phet media itself, which can develop SPS students (Widyaningsih, 2018). By using Student's Worksheet, learners are able to practice by using PhET media so that the competence to be achieved in this metamolism system material can be achieved. The adjustment of the use of learning media such as the use of computer media with the Internet network. The use of computer multimedia can be used as an alternative to improving students' science process skills (Siahaan P, Suryani A, Kaniawati I, 2017). Various attempts have been made by researchers to overcome these obstacles. There are using teaching techniques with a certain approach or some using tools as a medium of learning. In today's digital era, we use it in almost every aspect of life digital things (Sylviani, S, Permana, F.C, Rinjani, 2019). Even today there are several researchers who connect these things are local to the digital world, one of which is done by (F.C. Permana, AC Padmasari, 2019).

Under normal circumstances (not pandemic era), the large number of students and the lack of laboratory facilities in schools sometimes force teachers to carry out laboratory activities in crowded groups. In addition, related to safety issues, carrying out laboratory activities in a physical laboratory carries a greater risk due to the lack of caution of students in using laboratory equipment. Considering the problems faced by using science laboratories to carry out laboratory activities, virtual laboratories can be a better alternative to solve these problems (Tatli, Z., & Ayas, 2013). Especially in the current situation that requires all activities to be done virtually. Virtual laboratories simulate real laboratory environments and process and defined as learning environments where students convert their theoretical knowledge into practical knowledge by conducting experiments (Woodfield, 2005). It was designed and sequenced in such a way as to give a real impression in conducting an experiment (Tiwari, R., & Singh, 2011). Avirtual laboratories are sometimes the preferred alternative, or just a supportive learning environment for physical laboratories (Tatli, Z., & Ayas, 2013).

This study aims to determine the increase in motivation and understanding of the human metabolic system material through a PhET simulation. This research will discuss what exactly PhET Simulation, how students understand the metabolic system through PhET simulation, and how to increase student motivation after using PhET Simulation. This paper investigated the implementation of PhET simulation on student motivation in learning the metabolic system.

METHODOLOGY

The method used in this research was This study uses a Quasy Experiment research design. Quasy experiment is a single treatment design (one shot case study) which is the simplest design. A group of subjects was given treatment (X), then observations were made (Y). In this design, a group of research subjects received treatment, then

the variables to be observed were measured (Latipun, 2004). One shot case study, which is an experiment carried out without a comparison group and also without an initial test (Arikunto, 2005)

The research was conducted in one of private Junior High Schools located in Salatiga, Indonesia . In this study, the sample taken was class VII KH. Ibraham. By using purposive sampling, namely the selection of samples as desired (Latipun, 2004:50). Purposive sampling is a sampling technique used by researchers if the researcher has certain considerations in taking the sample. So sampling is done based on the existence of a particular purpose. The qualitative data were analyzed through a motivation rubric and a questionnaire. This research was conducted at SMP Muhammadiyah Plus Salatiga City in class VII-KH. Ibrahim with 10 students as respondents. Arikunto (2005), states that the population is the entire subject of the study. The population in this study were students of SMP Muhammadiyah Plus Salatiga. The variables analyzed in this study are:

- Treatment variable (X), what is meant by x in this study is the application of PhET simulation in the study of the metabolic system which is a treatment of this research.
- Observational variable (Y), what is meant by y in this study is learning motivation which will be observed after treatment, namely the application of PhET simulation.

The defining stages of preparation for the creation of student's worksheet range from identifying learning objectives, analyzing student characteristics, and analyzing learning materials. The activity at the design step is to explain the details of the Student's Worksheet developed based on the analysis of the characteristics of the students, the competencies to be achieved, and the characteristics of teaching materials. Development stage begins with developing student's worksheet and then validating the student's worksheet. If the student's worksheet developed has been validated, then proceed to the final step, which is to simulate before the researchers plunge the space.

The instrument used in this study used survey data. The survey is in the form of a questionnaire made in a google form so that it is easily accessible by students. The survey aims to reveal in detail about student motivation in learning the metabolic system using PhET simulation, while the type of survey uses a Likert scale. According to Sugiyono (2018), the Likert scale is used as a tool to measure attitudes, opinions, and perceptions of individuals or groups of people towards social phenomena. The Likert scale table is presented below.

Table 1. Skala Likert

Assessment Criteria	Scoring Scale
Very Agree	4
Agree	3
Disagree	2
Very Disagree	1

RESULT AND DISCUSSION

- **ABOUT PHET**

The PhET project has developed more than 80 interactive simulations. These cover various topics in biology and real world applications, such as the metabolic system. There are 16 simulations on topics of biology, as well as several earth science. A PhET simulation which requires several months to create, has 10,000 to 20,000 lines of code, and it is tested through a series of student interviews. These simulations are used worldwide and at all levels from high school through upperlevel university courses (Carl E. Wieman, 2008).

Regarding the design principles of PhET Simulation, one of which is carrying out the provision interactive media, there are several tools or tools provided to support this. These tools include click and drag which can be used to interact with features which is in the Simulai PhET Simulation. Sliders that can be used to increase or decrease parameter. Radio buttons that can be used to select between several options. Some Instruments such as a stop watch ruler, voltmeter, and thermometer are also available in the simulation can be used to take measurements. When students and teachers interact with this medium, they get new things that can immediately be felt about the effects of the changes they are making. This enabling them to investigate cause-and-effect relationships and answer scientific questions through simulation exploration. Another advantage that PhET has is that the PhET simulation also provides a wide choice of user languages can be used by various countries. Thus, for users who have difficulty

speaking English, still can use this application properly because there are many choices of languages available used (Sylviani, S, Permana, F.C, Rinjani, 2019).

The researcher produced the product of student's worksheet supporting PhET learning program application. Students gott the material on student's worksheet was metabolism system. The student's worksheet was applied to the guided inquiry model. It was used to support PhET learning media and it consists of 2 subsections for 2 meetings on the subject of metabolism and lifestyle. Each material was equipped with facts or events students often encounter in everyday life so that learning can be more contextual. Based on this, students were guided to explore their own knowledge through experiments and observations. Through such experiments and observations, students practiced using science process skills and scientific attitudes in the process of recognition of theories. By guiding students to find these theories, could play an active role in exploring knowledge so that learning could be more meaningful and memorable for them.

Student's worksheet developed by researchers is practical. Student's Worksheet was practically used in inquiry learning on static electricity because it facilitates and benefits students. Other research results showed that the student's worksheet used in the application of virtual lab media makes it easier for learners to understand learning (Sumargo E and Yuanita L, 2014). Other studies had shown that the student's worksheet could increase students activity during the learning process, allowing teachers to direct students to discover the concepts they were learning (Sintia R, 2014).

Good practise of PhET it self appeals to students in science learning *PhET provides dynamic access, and makes multiple experiments possible* (Moore E B, Chamberlain J M, 2014). Students become motivated in following the lessons using PhET. *PhET also describes things that are not seen directly by students* (Perkins K, Moore E, Podolefsky N, 2012). Base on the worksheet 1 on PhET simulation "eating and exercise", students can see the lifestyle and calories. In addition, the tools of the laboratory are rarely used and less well maintained most of the tools there are not worth using. In fact, the lab plays an important role in science education (Aydoğdu B, 2013). It makes the teacher must think of other ways that the competence to be achieved by learners can be connected. This is because a good teacher should learn how to engage students in scientific practice (Atkina, 2015). In today's digital era, most students have a strong tendency to like games in which there are challenges. PhET Simulation provides a form of "game" that students can do in class, after students understand the concept of fractions and also understand how the simulation works (F.C. Permana, AC Padmasari, 2019). In physics, chemistry, and biology learning, now you can use the PhET simulation application. The PhET simulation application can be used in many different educational settings, including levels of higher education, individual or small group inquiry activities, homework, and laboratories (Carl E. Wieman, 2010).

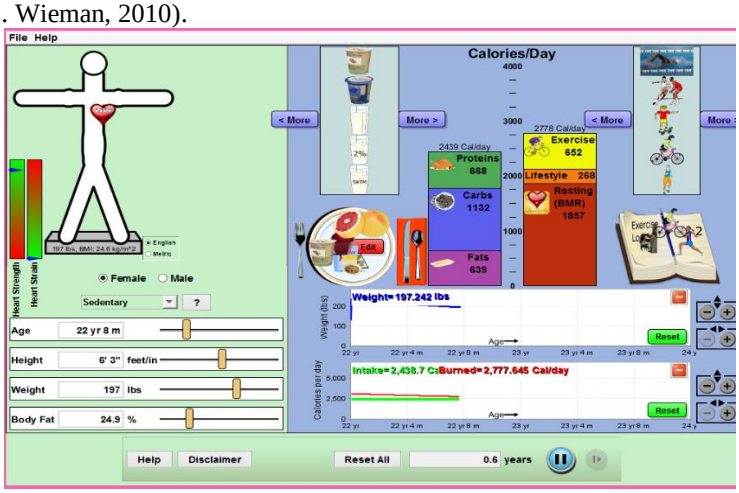

Figure 1. Display PhET Eating and exercise

- ## Effectiveness of Student's Worksheet

The meaning of learning is to learn which involves cognitive process. The development of critical thinking skills is not without challenges. In higher education settings, there is a mismatch between the vast topics required

completion every semester and the assigned weekly lecture hours (Zulkipli et al., 2020). At the junior high school level, the effectiveness of the student's worksheet can be seen from the cognitive outcomes of learners as measured by providing post-test. The total questions of the post-test is 10 consisting of multiple choice. Based on the results, Student's Worksheet supporting the application of the learning program successfully helped the learners in understanding the learning. The used of the student's worksheet and supporting learning media will make learning more meaningful (Mahfuziannor M, 2014). Other studies have also shown that Student's Worksheet based on guided inquiry using virtual labs can influence student's learning outcomes (Suliyowarni P A D, 2016)

Table 1. **Score Post-test**

Students	Score Post-test
001	8
002	8
003	7
004	8
005	7
006	8
007	7
008	8
009	8
010	8
Total	53
Average	7.57

To support the use of the media, students need a worksheet. This is so that the competence to be achieved in a learning can be fulfilled. Student's worksheet should contain the title, basic competencies, completion time, tools and materials used, brief information, steps of activities, tasks to be performed, and reports to be worked on. A worksheet is a tool used in learning to help learners in doing activities in sequence (Rahmi R, 2014). The students can manipulate and observe the real objects and materials that practical work can be defined as activities (Abrahams, I., & Millar, 2008). The students have to deal with hands-on activities to doing this practical work of course by them self. It is clearly known that hands-on activity in learning science is usually done in the laboratory, although it may be held in the classroom and field as well. In this context, laboratories are an essentialcomponent of education to make students gain experience (Tüysüz, 2010). The result shows that the students who learn the metabolic system with PhET simulation have higher both improvement in conceptual understanding and motivation than those who learn the metabolism system without PhET simulation as teaching media.

- ## STUDENT MOTIVATION

As a moderator for this study, motivation can be defined as an internal condition that functions to activate and direct the behavior (Kleinginna & Kleinginna, 1981). Herzberg has come out with a two_factor theory which encompasses motivation and hygiene theory. Motivation factors consist of achievement and recognition; it highlights positive academic attitudes which fulfill the desire for self_actualization (Halif et al., 2020). According to Nasution (1992), motivation to learn is a condition that makes a person willing to try to learn. According to Selvi (2010), online learning is often required to more motivated because the learning environment usually depends on motivation and related characteristics of curiosity and self-regulation to involve in the process learning. In fact, technology itself can be seen by some as intrinsic motivation because it provides a number of qualities that are recognized as important in foster intrinsic motivation, namely challenge, curiosity, novelty and fantasy (Lepper et al., 2005; Lin et al., 2008), motivation is considered an important factor for learning success is included in the online learning environment, so the need for reconsider learning motivation in a learning environment that utilizes

technology (Harandi, 2015), for this reason it is important for researchers to world of education to examine in depth about how students' motivation in online learning, especially learning activities are carried out during Covid-19 pandemic. The aspects studied in this study are related to aspects of described by (Hamzah B. Uno, 2009) who wrote 8 indicators of learning motivation, namely concentration, curiosity, enthusiasm, independence, readiness, enthusiasm or encouragement, never give up, and believe in yourself.

This research was conducted with the aim of providing an objective picture of how students' learning motivation in online learning is during the Covid-19 Pandemic, so this is an evaluation material in create effective online learning in the midst of the Covid-19 Pandemic, besides that This research can also be used as a study material for other researchers related to student motivation at school online learning during the Covid-19 Pandemic. Thus, motivation is the drive within the individual to achieve certain goals. There are two types of motivation, namely intrinsic motivation and extrinsic motivation. Intrinsic motivation, is motivation that is influenced by internal or personal factors of a person without any coercion from others. Extrinsic motivation, is motivation that is influenced by factors from outside the individual or motivation that arises due to the influence of the environment.

Increasing students' learning motivation can automatically affect their learning. Learning outcomes are determined by the combination of children's basic abilities and seriousness in learning. Seriousness is determined by children's learning motivation. In increasing student learning motivation, a teacher needs to innovate in learning, namely by using an effective and innovative learning approach (Depdiknas, 2000). The experience of students who grow up from the family environment and the surrounding community is a very valuable material, and can be developed in learning. With assignments from the teacher, students work together to solve problems and respect each other, so that relationships between students will be more harmonious, and students' writing results will be better by integrating the thoughts of all members.

The second variable analyzed in this paper is student motivation. The data obtained by questionnaire of motivation. The questionnaire developed by the researcher is adapted from three design questionnaires; Computer Attitude Questionnaire (CAQ) by (Christensen, R., & Knezek, 1996), science motivation questionnaire by (Glynn, S. M., & Kobala, 2006), and determination theory perspective questionnaire (Deci et al., 1994).

For science motivation aspect, the group has same condition before and after learning the metabolism system without using PhET simulation. While the group, they are slightly increasing condition before and after using PhET simulation as media learning for eating and excersize topic. The last aspect is the self-perspective determination, where the students have an opinion about using PhET simulation as teaching media in learning eating and excersise topic. The learning environment affects how and the extent to which student’s perceptions of them learn and retain knowledge (Luketic, C. D., & Dolan, 2013). Based on the data result above, before this research the students did not use PhET simulation as media learning. The researcher used Power Point Presentation or another media teaching to deliver the materials. Therefore, it resulted in different perspectives between before and after about used PhET simulation. As the result, they were fairly motivated in learning eating and excersise topic. Nevertheless, if we compare it, the students before used PhET Simulation still showed lower motivation than the students after used PhET Simulation. Because the same condition of pretest as a posttest that they were treated. While the students, they slightly performed different condition between the pre-test and post-test. They were motivated when they were learning metabolism system using PhET simulation.

Table 2 The results of the motivation questionnaire.

Indicator	Questions	Very agree	Agree	Disagree	Very disagree
Enthusiasm	Is this program interesting to use?	70%	10%	10%	10%
	Is this program easy to run by users?	60%	20%	10%	10%
	Is this program reduce user saturation in studying metabolic systems?	60%	20%	10%	10%
Curiosity	Are you interested in using this application as an additional learning medium in learning the metabolic system?	60%	20%	10%	10%

Indicator	Questions	Very agree	Agree	Disagree	Very disagree
Self-Confidence	If the teaching teacher uses this application in teaching, will it help the learning process?	70%	20%	10%	0%
	Is the language used in the application easy for the user to understand?	70%	20%	10%	0%
	Is the material be understood through the visualization provided?	70%	20%	10%	0%

Students who have high learning motivation have the desire to get good grades so that to achieve these goals students study well and diligently. High student learning motivation can be seen based on indicators, one of which is related to concentration, according to Azizah (2015) that concentration will make students understand the material being taught. This is based on the fact that attention will be focused on what is attracting students.

The first indicator is related to enthusiasm and encouragement, while the aspect studied is the desire to get the best value from each task with a percentage of 70%, 60% and 60% for the scale strongly agree with very good criteria, it shows that students have enthusiasm and encouragement which is very strong to get the best value from each task given after the learning process. The desire to get the best grades must be encouraged by high effort and hard work both in the process of learning activities and when working on learning assignments.

The second indicator related to learning motivation is student curiosity. Curiosity is a very important initial capital in the learning process, with high curiosity, the desire will encourage students to find what they want to know (Fauzi et al., 2017). The aspect of curiosity studied was interest in the materials and materials presented with a percentage score of 60% including good criteria, so it can be interpreted that students are able to have the courage to ask questions so as to create active learning and create two-way learning not only one way.

The last, third indicator is self-confidence, while the aspects studied include being confident in doing assignments with a percentage score of 70% including good criteria so that it can be interpreted that students have good self-confidence with scores or results from assignments that have been done. The desire to get the best value from each lesson has not been seen in the students' self-confidence, this shows that some students still feel less confident about the tasks they have done.

Students showed good responses about PhET simulation as a teaching media in the learning process. They were very enthusiastic when they used PhET Simulation about the metabolism system. Because they could explore more the abstract concept and they could solve the problems from the worksheet that was given to them. PhET simulation is a very interactive medium. Thus, the higher the student's achievement on learning the metabolism system.

This questionnaire is one of the instruments used to obtain information that is not obtained through observation. This information is a student's response to teaching and learning activities that train students' abilities in learning metabolic systems using PhET simuation. Student responses to the use of PhET simulation in learning metabolism systems were analyzed as follows:

Based on the recapitulation of the results of student responses to the use of PhET simulation, it shows that the highest increase in response was achieved in the question “Is the material be understood through the visualization provided?”; “If the teaching teacher uses this application in teaching, will it help the learning process?”; “Is the language used in the application easy for the students to understand?”; that is, 70% of students strongly agree and 20% of students agree. However, overall there was a positive response and most of the students were able to understand the learning of the metabolic system using the PhET simulation.

Motivation is something that can foster students' desire to be involved in conducive learning. Student motivation is measured from the observation sheet and student motivation questionnaire which contains statements suggesting that someone has high motivation. The observation sheet contains motivational indicators, including doing exercises, is not easily distracted during learning, asks questions when it is unclear, and gives responses. Motivation is an important part of a person, especially students, really needs good motivation to be able to follow learning well. Without motivation, a person will not have a clear purpose in life.

The intrinsic motivation and extrinsic motivation are two kinds of motivation. Intrinsic motivation is motivation that is influenced by internal or personal factors without any coercion from others. Extrinsic motivation is motivation that is influenced by factors from outside the individual or motivation arising from the influence of the

environment. Increasing students' motivation to learn can automatically affect their learning. Learning outcomes are determined by a combination of the child's basic abilities and seriousness in learning. Seriousness is determined by children's learning motivation. The experiences of students who grow from their family and surrounding communities are very valuable materials, and can be developed in learning.

CONCLUSION

The result showed that the students who learn the metabolisme system with PhET simulation have higher both improvement in conceptual understanding and motivation than without those who learn metabolism system PhET simulation as teaching media. My suggestion for future researchers is to add references from other studies in order to compare the results to get more detailed findings.

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