ORIGINAL ARTICLE

Introduction and Testing about Development the Technology-Based EIGEC Models to Enhance Student Learning Outcomes

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ABSTRACT

The purpose of this study was to introduce technology-based EIGEC models and implement these models into the learning process in the classroom. This research was quasi-experimental, using a pre-test-post-test control group design. The research sample consisted of two classes with different treatments. Each course was selected randomly, with the number of students who were the object of the trial being as many as 36 in each class. The data collection technique used an instrument test and was analyzed descriptively and inferentially. The T-test was used in inferential analysis to determine how the model's implementation and impact on learning outcomes were affected. The analysis found that the technology-based EIGEC model contributed 0.59 to improving learning outcomes compared to conventional models (0.39), based on the results of the N-gain value. The five stages of the technology-based EIGEC were (1) engagement, (2) introduction, (3) guidance, (4) execution, and (5) conclusion. From the analysis results, the technology-based EIGEC model can be an example of a model used to support learning in the classroom.

KEYWORDS: Learning outcomes, Technology-based EIGEC models, Team based learning, Problem based learning

INTRODUCTION

Nowadays, there are many learning models used to meet the needs of 21st-century learning, especially in science education in schools, some of which are problem-based and team-based learning (TBL) models. Problem-based learning (PBL) is an educational approach where problems are the starting point of the learning process. The type of problem depends on the particular form. Most problems are based on real-life events chosen and changed to meet educational goals and standards. However, it could also be a matter of hypothesis. The problem becomes very important as the basis of the learning process because it determines the direction of the process and places more emphasis on the formulation of questions than answers. It also allows learning content to be related to context, which drives student motivation and understanding as a force that leads to consistency with the way assessment is carried out (Graaff, 2003). In PBL, the learning process is directed toward independent learning, with a much more individual-oriented focus.

Students can usually define their problem formulation in the given subject area guide. In other cases, the teacher establishes the problem, and students use this as a starting point. In a PBL setting, learning is triggered by a situation that requires solving.

Dewey explained the cognitive element of learner engagement by describing how the origins of thoughts are presented as "confused doubts" triggered by "something specific". Students connect with these "confusions or doubts" by activating their prior individual and collective knowledge and finding sources; they also engage in peer learning through small group discussions and consolidate their learning through reflective writing. As well as enabling students to understand concepts and subject matter, these learning experiences may also help students "develop an understanding of themselves, and the context in which they operate, as well as the ways and situations in which they learn effectively" (Yew and Goh, 2016, pp. 1-5). PBL models can help students contextualize content knowledge and thereby promote knowledge transfer. Ghufron and Ernawati (2018) say that implementations that use the PBL model for learners or case-based instruction with problem-solving activities can have less of an effect on students' ability to learn on their own, solve problems, and deal with uncertainty.

However, behind all that, the PBL learning model has several weaknesses, including (a) the learning environment needs further attention so that students need to understand the PBL model and master the concept first, and the PBL model has not shown to be able to practice skills (Batdi, 2014; Celik et al., 2011); (b) students do not have interest in or confidence that the problem can be solved, so they will feel reluctant to try; (c) the success of the learning model through PBL requires sufficient preparation time, but without understanding why they are trying to solve the problem being studied (Fitria et al., 2019). Competency-based learning through PBL in small groups requires more time than large-group seminars (Cónsul-giribet, 2014; Ocon, 2012). Therefore, it is necessary

to pay attention to several alternative solutions to overcome this by presenting a design concept that can accommodate, in particular, the efficiency and effectiveness of time during the learning process. It is intended that learning can proceed according to what has been planned in the learning objectives.

TBL is one of the learning models used in 21st-century learning. TBL is a relatively new education model that integrates direct and active instruction elements with collaborative learning in small groups. TBL is usually arranged in three phases. The first phase is the individual preparation phase. During this phase, students study book chapters, articles, or digital resources, as determined by their teacher. The second phase is the readiness assurance phase. The third phase is the application phase (Rotgans et al., 2019). TBL provides opportunities to continue teaching engagingly, caters to large numbers of students, provides immediate feedback, involves students in decision-making, and encourages active small-group and class discussions (Burgess et al., 2014; Lee and Waites, 2013). TBL goes beyond the simple transfer of content to the application of knowledge through conceptual and procedural problem-solving (Michaelsen and Sweet, 2008). In recent years, TBL has gained popularity in medical and health education as a resource-efficient, student-centered teaching pedagogy, sometimes introduced as an alternative to PBL (Burgess et al., 2020; Yuretich and Kanner, 2015). The application of the TBL model can stimulate students to analyze the problems given by the teacher so that they can answer and give reasons. The TBL model is used when students need to understand important information, answer difficult questions, solve problems, and be personally responsible for ensuring that the opinions expressed are correct and can be explained (Buchin, 2018; Marin and Halpern, 2011; Nursulistyo, 2021).

As a follow-up to the previous explanation, TBL has several drawbacks. The analysis of literature sources found several areas for improvement in the TBL model, namely, (a) communication problems. "It is challenging to work in groups because of overlapping information, and deciding as a group what to include and not include can be stressful (Watkins et al., 2018, pp.217-219); (b) the lack of enthusiasm of students when they have to switch to a different learning method. This problem, however, can be overcome by a well-crafted course design (Hunt et al., 2009); and (c) time-consuming tasks requiring input from a large number of academics with varying expertise, ensuring academic involvement and understanding of new teaching methods and content, and standardization in delivery (Burgess et al., 2014).

Aside from these two learning models, technology is an essential part of learning in the 21st century. Technology exists as a supporting medium in the learning process. Technology serves as a tool to explain abstract concepts or designs. It is, of course, advantageous, especially in science-physics learning. Learning about science and physics, which have a lot of abstract ideas that cannot be explained directly, is a great way to pass on knowledge, especially understanding. People think that technology is very important for this, so the role of technology in the classroom must be linked to the learning system to help the learning process.

Based on the weaknesses of both problem-based and TBL models and the need for technology in learning, the authors formulate a new learning design that incorporates technology elements as an essential point in developing learning models. Technology is incorporated into the learning model, developed either in a virtual laboratory or on mobile devices, and functions as a tool and an integral part of the learning process. The design of this learning model is called technology-based EIGEC (Engagement, Introduction, Guidance, Execution, Conclusion), which focuses on student involvement, responsibility, motivation, and time efficiency in the learning process, whose output is student learning outcomes. It is undoubtedly very impactful because some of these elements are the main components of supporting student learning in class. This study will likely provide up-to-date contributions and ideas related to learning models that focus on the use of technology, especially in the form of adaptive technology and adaptive learning.

LITERATURE REVIEW
Problem Based Leaning

PBL is a way of teaching that lets students do research, combine theory and practice, and use their knowledge and skills to come up with solutions to problems that have already been defined (Hartman et al., 2013). PBL is based on investigating, explaining, and solving big problems through hands-on learning (Barrows, 2000; Torp and Sage, 2002). In PBL, students work in small collaborative groups and learn what they need to know to solve problems. The teacher acts as a facilitator to guide students through the learning cycle described. Students are given a problem scenario during this cycle, known as the PBL tutorial process. Students formulate and analyze the problem by identifying relevant facts from the scenario. This fact identification step helps students represent the problem. When students understand the problem better, they generate hypotheses about possible solutions. An important part of this cycle is identifying knowledge gaps related to the problem. These knowledge gaps become what are known as "learning problems," which students research during self-directed learning (Hmelo-Silver, 2004). Siagan et al. (2019) wrote in their article regarding the syntax of PBL, as presented in Table 1.

The syntax in the PBL-based learning process can facilitate students' practice and improve their in-depth understanding of their capacity to apply the concepts obtained (Jailani et al., 2017). In a PBL environment, learning is driven by authentic and unstructured problems. Students work together to figure out the problems and how to solve them (Pecore, 2013), which helps them develop and improve their communication, presentation, and critical thinking skills. PBL is a way of teaching and learning that puts the learner at the center of the

curriculum and gives them the power to do research, combine theory and practice, and use their knowledge and skills to come up with workable solutions to given problems (Savery, 2015). Based on the theory of constructivism, PBL starts with students using what they already know and making connections between what they know and what they are learning. Students work together to clarify and define the problem, come up with solutions based on what they know, and figure out what they still need to learn about the problem. By doing independent learning, students try to fill in those gaps and finish the learning process by sharing what they have learned.

Furthermore, there needs to be more agreement on how PBL affects students' academic outcomes. This is mostly because of how outcomes are measured. In some cases, Capon and Kuhn (2004) and Gijbels et al. (2013) found that PBL had no effect on students' declarative knowledge but had a big effect on their ability to integrate, apply, and transfer that knowledge across many different fields. As shown in results of the journal literature review showed that the PBL model has some flaws. The analysis of shows that even though the PBL model helps students learn a lot more, it also stresses many of them. One of the elements is the time needed to build students' understanding. In addition, many students need clarification in completing various instructions because, often, student involvement could be more optimal in PBL models, especially regarding student responsibility during the learning process. This certainly impacts the learning pattern built, which should be how to optimize learning so that the expected goals can achieve in the learning process.

Nevertheless, on the other hand, this is certainly inversely proportional when viewed from some of the journal analysis results found. Another factor found in PBL is that sometimes students need help understanding the problem at the beginning; so many students are not responsible in the learning process, which is certainly independent of student motivation. This can certainly have a negative impact if it cannot be anticipated or found a solution. Filgona et al. (2020) wrote that learning success depends on whether or not students are motivated. Motivation drives learners to achieve learning goals. It is important to recognize that motivating learning is central to good teaching.

TBL

TBL may rely more on small group interaction than other teaching methods commonly used in post-secondary education. TBL is designed to equip students with conceptual and procedural knowledge. In a TBL class, some time is spent making sure that students understand the course material, but most of the time is spent on team assignments that focus on using the course material to solve problems that students are likely to face in the real world (Michaelsen and Sweet, 2008; Burges et al., 2020).

One of the biggest advantages of TBL is that it shifts the role of the teacher from one who is solely responsible for mastering and delivering the entire subject matter to one directing the classroom, while the effort of mastering the material is taken over by the students and carried out in the process of managing their respective groups. If the teacher wants to deliver a lesson using the TBL approach, then the teacher must design the lesson from start to finish, which is done long before the semester begins. This design process includes deciding on activities in four stages: Before the class starts, on the 1st day of class, each main unit of instruction, and when approaching the end of the semester/lesson (Falahah, 2006; Chung et al., 2009; Koles et al., 2010). TBL allows students to enhance their ability to work in groups and promotes active learning. The team learning process seeks to develop a blend of understanding of general management processes applied to specific planning and management topics for each group as a form of hard skills and expected soft skills related to collaboration, initiative, presentation, and communication (Mennenga and Smyer, 2010; Pardamaean et al., 2022). The TBL phases are presented in Figure 2.

TBL is characterized using permanent student work groups throughout the semester, a readiness assurance process at the start of each instructional unit, and most of the class time spent on small team activities, such as application exercises (Michaelsen and Sweet, 2008). Thus, at the beginning of each instructional unit, students take an 'assurance readiness test' (known as iRAT). The test consists of a multiple-choice test

Table 1: Syntax of problem based learning

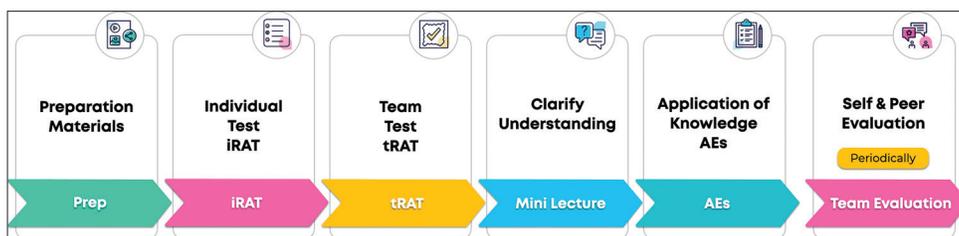| Phase	Activity
Phase 1	Orient learners to the problem
Phase 2	Organizing learners to learn
Phase 3	Guiding individual and group investigations
Phase 4	Developing and presenting work
Phase 5	Analyzing and evaluating the problem-solving process

Figure 1: The procedure of team-based learning
Source: https://docs.lamsfoundation.org/tbl/tbl-for-students/tbl-as-student

based on the previously allocated reading. Immediately after submitting their answers to the test (and before receiving the results), students take the same iRAT test again, this time in predetermined teams of students. The iRAT is conducted using an answer sheet, where teams put a cross over the letter corresponding to the answer, they consider to be correct. An asterisk under the silver lining indicates the correct answer. If students have chosen the wrong answer, they continue answering iRAT questions until they find the correct answer.

However, from these statements, some studies highlight students' and students' willingness to work in teams. Some mention that when working in teams, some students find it difficult, sometimes causing confusion/frustration and time-consuming, so learning becomes ineffective (Lejk and Wyvill, 2001; Islam et al., 2021; Lancellotti and Boyd, 2008;). It was found that some students prioritize their individualistic personalities and dislike working in teams (Wagner, 1995), with "lone wolf" preferring to work alone because they dislike other people's ideas, dislike group processes, and often see others as inferior (Chad, 2012). Similar results were found from the analysis of the literature study, as shown the results of problem identification in the TBL model are related to student enthusiasm for learning. This is certainly one of the main factors where student enthusiasm will play an important role during the learning process. Not enthusiastic students will cause less than optimal interaction patterns between teachers and students or students in their groups. Student enthusiasm can also be observed in student involvement, especially in learning. Enthusiasm can be characterized by responding to questions given by the teacher or answering questions given. Students' enthusiasm in the learning process or teamwork will positively impact the continuity of the learning process in terms of individuals and groups.

Moreover, enthusiasm will arise if the learning process is designed to maximize students' involvement in the learning process. Another area for improvement of TBL is the pattern of understanding and communication that needs to be maximized in linking overlapping information, especially in group communication. Another thing that is considered one of the weaknesses of TBL is that the argumentation pattern is not presented explicitly, so students' argumentation skills cannot be measured directly. Therefore, looking at some weaknesses to build student enthusiasm in the learning process, student involvement becomes the main point in developing instructional designs that will be made later.

METHODOLOGY

This study is classified as descriptive quantitative research because it is quasi-experimental with a one group pretest-posttest design. In introductory physics courses on two-dimensional motion and rigid body, design research was tested. Classes are divided into classes A and B, with 36 students in each class. Class A applied the EIGEC model, and Class B used the learning model (conventional model), which was often

carried out with trials carried out for five meetings (1× meeting/week) (Table 2).

The research questions were: (1) Is there an effect of the EIGEC learning model on learning outcomes? and (2) Are there differences in learning outcomes between students taught using the EIGEC model and students taught using the conventional model?

The tested aspect relates to learning outcomes achieved using technology-based EIGEC in classroom learning. The test instrument consisted of essay questions consisting of five question numbers, while the data analysis techniques used descriptive analysis techniques and inferential analysis (normality tests, homogeneity tests, and T-tests). The descriptive analysis uses the N-gain value equation to determine the average value, standard deviation, and increased learning outcomes between the pre and post-tests. Meanwhile, the T-test was conducted to see the effect of the EIGEC learning model on learning outcomes in the experimental class and to show differences in learning outcomes between the EIGEC model and the conventional model applied so far in the learning process. The research procedure consists of the preparation stage, the implementation stage according to the model syntax, and the evaluation stage.

FINDINGS

Technology-based EIGEC learning design is a way of learning that focuses on getting students to work together in groups. It does this by incorporating technology into the learning process, emphasizing process skills, and making the best use of time. In this learning model, the authors consider that student involvement at the beginning of learning, or before learning begins, is significant to building students' attention in the learning process. The authors believe students will have good
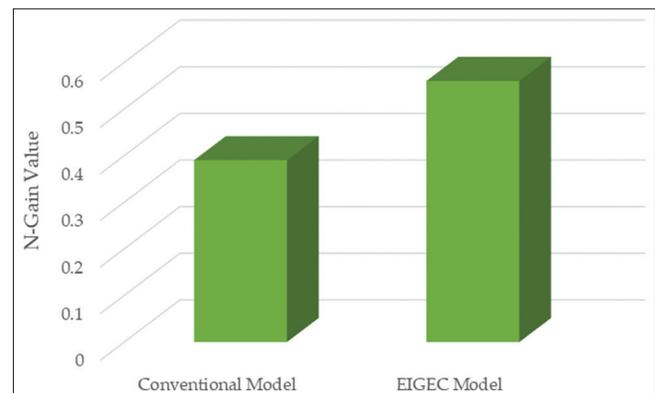
Figure 2: The value N-gain learning outcomes

Table 2: One group pre-test-post-test design

Variable	Pretest	Treatment	Post-test
Experiment Class	X_1	C	X_2

Note: C=EIGEC model

involvement in learning or high motivation when learning or before starting to learn. It is based on observation and follow-up research results, which show that students' attention or likes or dislikes in the learning process depend on how the teacher opens the lesson.

The EIGEC technology-based learning model was made to fix the problems with the problem-based and TBL models, which did not show how the teacher gets students involved and motivated at the start of learning. In addition, these two models require significant time to implement problem-based and TBL, both of which are references to learning models in the medical world. The author and researcher focus on simplifying the two models so that they can be implemented in the world of education, especially at the high school or college level, with the principle of time efficiency. These two models exist to improve some of the components that are lacking in them so that they are filled with new things that become the scope of the development of the world of learning, especially those that are affected by the learning trends of the current century.

The characteristics of the developed learning design consist of several constituent elements, namely: (1) Student involvement at the beginning of learning is the main point in the continuity of learning; (2) problems are presented in the form of simple questions in the form of concepts related to the material to be studied; (3) the use of technology is the main point in implementing the technology-based EIGEC Learning design; (4) the group is divided into several teams consisting of 3–4 people; it is intended that each student has individual responsibility related to the group; (5) in the process, the adaptive technology group is the basis for completing the assigned tasks; and (6) evaluation and feedback are presented comprehensively so that evaluation and feedback can be accommodated as a whole by the expected learning outcomes. In the physics education department at Halu Oleo University, one introductory physics class was used in a small test. The analysis results are presented in Tables 3-5.

Based on the results of the descriptive analysis in Table 3, student learning outcomes obtained an average pre-test of learning outcomes before applying the conventional model of 53.17 with a standard deviation of 15.18 and an average post-test of learning outcomes after implementing the conventional model of 72.64 with a standard deviation of 9.80. The average score of the pre-test of learning outcomes before applying the technology-based EIGEC was 47.56 with a standard deviation of 14.19, while the average score of the post-test of learning outcomes after implementing the technology-based EIGEC model was obtained at 77.97 with a standard deviation of 9.07. The average N-gain value of the conventional model is 0.39 with a standard deviation of 0.18; this means that the overall learning outcomes are moderate. It shows that the conventional model has a good influence on improving student learning outcomes. The average N-gain value of the technology-based EIGEC model is 0.56 with a standard deviation of 0.18; this means that the overall learning outcomes are moderate. It

displays that the technology-based EIGEC model has a good influence on improving student learning outcomes.

Figure 2 shows that the N-gain value of student learning outcomes by applying the conventional model is 0.3–0.4. It means that using traditional models leads to a moderate increase in learning outcomes. The N-gain value of student learning outcomes using the technology-based EIGEC model is 0.5–0.6. It indicates that the increase in learning outcomes using the technology-based EIGEC model is moderate. Hence, we can say that using the technology-based EIGEC model to improve learning outcomes is better than using traditional models to improve learning outcomes.

Based on the Kolmogorov–Smirnov data normality test results in Table 4, it was found that the sig. for the N-gain-conventional model data and the N-gain Technology-Based EIGEC Model data, namely, sig. $P > \alpha$ (with $\alpha = 0.05$), then H_0 is accepted, or H_1 is rejected. As a result, the N-gain model conventional data and the N-gain model technology-based EIGEC data can

Table 3: Descriptive analysis

Variable	Average±Standard deviation
Conventional model-pre-test	53.17±15.18
Conventional model-post-test	72.64±9.80
Technology-based EIGEC model-pre-test	47.56±14.19
Technology-based EIGEC model-post-test	77.97±9.07
N-gain - Conventional l model	0.39±0.18
N-gain- Technology-based EIGEC model	0.56±0.18

Table 4: Normality test

Variable	Sign
Conventional model-pre-test	0.759
Conventional model-post-test	0.238
Technology-based EIGEC model-pre-test	0.440
Technology-based EIGEC model-post-test	0.339
N-gain - Conventional model	0.251
N-gain - Technology-based EIGEC model	0.221

Significant P>0.05

Table 5: Homogeneity test

Variable	Sign
Pre-test – Conventional and technology-based EIGEC	0.937
Post-test – Conventional and technology-based EIGEC	0.208
N-gain – Conventional and technology-based EIGEC	0.902

Significant P>0.05

Table 6: Result of T-test

Variable	Sign
Post-test – technology-based EIGEC model	0.019
N-gain – technology-based EIGEC model	0.000

Significant P>0.05

be concluded to be normally distributed (or that the sample data studied comes from populations with normal distribution).

Based on the results of the homogeneity test in Table 4, it was found that the value of Sig. $P > \alpha$ (with $\alpha = 0.05$), then H0 is accepted, or H1 is rejected. Thus, it can be concluded that the pretest data of the conventional model and the technology-based EIGEC model and the posttest of the conventional model and the technology-based EIGEC model have a homogeneous data distribution.

Based on the T-test results in Table 6, it was discovered that if the sig. P-value is 0.05, then H_0 is accepted and H_1 is rejected. Thus, the learning outcomes of students taught by applying technology-based EIGEC in multimedia classes increase significantly.

- Hypothesis 1: H0 = There is an influence on learning outcomes by implementing technology-based EIGEC in multimedia classes; H1 = No effect on learning outcomes by implementing technology-based EIGEC in multimedia classes.

- Hypothesis 2: H0 = There is an increase in learning outcomes by applying technology-based EIGEC in multimedia classes; H1 = There is no increase in learning outcomes by applying technology-based EIGEC in multimedia classes.

DISCUSSION AND CONCLUSION

Introduction about Technology-based EIGEC Learning Models

Design technology-based EIGEC learning models are a form of learning design that prioritizes student involvement at the beginning as the main gate to understanding the nuances of students' feelings and how they interpret the learning process that will be carried out in class. The author preliminary observations in elementary school level in West Nias Regency found that (1) one thing that makes students interested in what we are going to teach is how a teacher is able to provide positive feedback at the beginning of learning, (2) students will be interested if the apperception and motivation stages are presented in the form of different things, for example questions are presented in the form of a written test where the teacher distributes sticky notes to each student and students answer and paste on the blackboard, (3) In building communication with students, do not give questions that are difficult in accordance with the range of students' thinking abilities because different locations will have different patterns of abilities in nature, (4) students will be interested in the learning process if learning is packaged by presenting learning videos both in the form of displays on smartphones or laptops; (5) not all students are able to work together in teams, this is because some students sometimes prioritize ego, especially classes that have different cognitive levels; (6) in giving instructions for teamwork related to the material to be worked on students often need a process of explaining repeatedly so that they understand what will be conveyed; and (7) the way the teacher conveys the material is one of the factors that makes students enthusiastic about learning.

In the EIGEC learning technology-based design, the phases are designed to suit the needs of the learning process in schools. In the first phase, for example, there are things like engagement and the features of this learning design. In the PBL model, parts of how students are involved are explained indirectly. Instead, the focus is on how students feel about the material they will learn. In addition, the stages of organizing students to learn and guiding individual and group investigations in the learning model are simplified into a guidance phase where, in this phase, students will be given explanations and guidance regarding assignments or experiments that will be carried out individually or in groups.

Meanwhile, in the TBL phase, the pre-preparation stages and individual readiness assurance test (iRAT) are simplified into an introduction stage, with responses and problem analysis. At this stage, students will be given simple questions related to the material being taught, either direct questions or questions. In this phase, the response stage, it is recommended to use technology currently being developed, for example, using Padlet, Mentimeter.com, Kahoot, and Quizizz. In addition, the stages of understanding application, clarification session, and peer evaluation are simplified into an execution stage. The word "execution" means that all participating in it participate in the learning process. In student-centered learning, the teacher is a facilitator who meets the necessary needs. The group test is presented after the discussion activity is over. The following presents each stage of the technology-based EIGEC learning design.

First: Stage of engagement

This stage aims to: (1) Increase learner attention before learning; (2) increase learner motivation; (3) increase learner knowledge and understanding of the topic being taught, and (4) build perceptions about the material. It is best to use modern apps like Padlet, Menmeter.com, and the like to find out what students think about the learning process. At this stage, it is recommended to build interesting communication with students, for example, by showing a learning video. It is expected to build learning engagement in the early stages of learning — the learning objectives present involvement as a response or arousing perception by involving technology. The engagement stage is made up of building ideas about the concepts being taught and getting people to think about what they already know about the topic by stating the problem to be solved.

At this stage, student engagement can be the glue that holds together all aspects of student learning and growth. Student engagement makes teaching more fun, engaging, and rewarding and has been shown to have a significant impact on students. When students show high levels of behavioral, emotional, and cognitive engagement, they do well in school, feel more connected to their school, and feel better about their social and emotional well-being. As written by Martin and Bolliger (2018), student engagement increases student satisfaction, increases student motivation to learn, reduces

feelings of isolation, and improves student performance in online courses. Martin et al. (2018) also conveys the importance of student engagement for learning because they believe student engagement can be demonstrated as evidence of the sufficient student effort required for their cognitive development and the ability given to create their knowledge, leading to high student success rates.

Second: Stage of introduction

At this stage, student involvement can be the glue that holds together all aspects of student learning and growth. Student engagement makes teaching more fun, enjoyable, and rewarding and has been shown to have a significant impact on students. When students demonstrate high levels of behavioral, emotional, and cognitive engagement, they excel academically, form a stronger sense of connection with their school, and have a more positive sense of socio-emotional well-being. As written by Martin and Bolliger (2018), student involvement increases student satisfaction, increases student motivation to learn, reduces feelings of isolation, and improves student performance in online courses.

Third: Stage of guidance

At this stage, it is presented in two forms: explanation and preparation. Before getting into the core activities, which are teamwork and discussion, students should understand the material and how to do the work. So that when in the teamwork phase, students will more easily do the assignments given. In addition, the general objectives in this phase are: (1) Provide explanations for the topics being taught; (2) Provide knowledge related to the instruments used; (3) guide the use of tools and things that need to be demonstrated in work (if it involves laboratory equipment, applications, or software in learning. In this phase, the learner is given guidance on the task or project. The tasks or projects involve experiments or technology digital tools that support the learning process. This activity begins with the teacher explaining the material to be provided, the topics to be worked on, and providing guidelines for using technology so that students can easily digest the content that will be carried out.

Moreover, the explanation from the teacher will be better understood by the students' minds. Hiebert et al. (2007) suggested that teachers must know what specific responses say about students' thinking. What students must know to provide responses, be involved in this analysis, and know what responses are considered evidence learning. In addition, Ankiewicz et al. (2006) and Parmin et al. (2016) wrote that integrating science and social life requires an organized learning procedure so that the procedure for transforming knowledge is presented conceptually and reconstructing new knowledge. Tailored instruction and explanations allow students to better engage in knowledge construction and broaden and deepen their understanding. Adaptive instruction not only has the potential to transform traditional classrooms but also creates the possibility of a fun learning atmosphere as it allows students to learn at their own pace and receive immediate feedback (Cueli et al., 2016; Izumi, 2013).

Fourth: Stage of execution

This stage consists of two parts, namely, teamwork and discussion. This phase aims to train group cooperation and the responsibility of each individual. In this phase, each group and individual are responsible for the assigned task. Groups are presented as a team of three to four members, so each member is trained to accept one another without prioritizing ego over others. Rusiana (2016) writes that group-based learning is packaged in a particular form of learning with specific sequences of individual work, group work, and direct feedback to create a motivational framework in which students are increasingly accountable to each other for coming to class ready and contributing to the discussion. Through good teamwork, children produce satisfying work. In this teamwork phase, the teacher presents assignments or projects that involve technology, for example, using physics education technology, an electronics workbench, a tracker, or applications relevant to the material presented.

The teacher is advised to integrate technology into each project or assignment at this stage. Some of the learning strategies used in the design and implementation of the studies shown in this search include the following: (1) Students have the opportunity to collaborate, work together, and organize their teams (Zhonggen and Wang, 2016); (2) Each study unit contains an introductory example along with an explanation (Bednall and Kehoe, 2009); (3) Students are not only given instructions to complete assignments but also have the opportunity to search for information in the database provided to them or the internet (Shih et al., 2010); (4) Prompts must be critically reviewed to be effective in a personalized and adaptive learning environment (Ifenthaler, 2013); (5) Pre-reflective cues should be used to encourage reflection before dealing with content (Ifenthaler, 2013). Furthermore, after the teamwork phase ends, the discussion phase begins. The discussion phase begins with each group presenting their project related to the findings, results, or summary, which includes data, tables, and graphs. Each group presents the findings given, and other groups provide feedback related to the task or project given.

Fifth: Stage of conclusion

The conclusion stage contains an evaluation and feedback section. This phase aims to: (1) Make judgments about a program, increase its effectiveness, and inform programming decisions; (2) help students reflect on their learning and learning strategies to make adjustments to improve student learning. Huljanag (2021) argues that learning evaluation is critical to determining whether or not educators implement a learning system. Because an educator needs to conduct an evaluation, it is the same as if the educator has made no progress in designing a learning system. In the evaluation section, the teacher presents simple questions related to the learning process that has been carried out and the results obtained. This activity can

provide opportunities for participants to recall memories at the beginning regarding what they are trying to build during the learning process. Meanwhile, at the feedback stage, the teacher provides input regarding what still needs improvement and what needs to be improved. Izzati (2022) wrote that having feedback in the learning process can help students develop knowledge-building skills.

Testing about Technology-Based EIGEC Model

The results of the technology-based EIGEC trial, as presented in the analysis, found that the EIGEC learning model could improve student learning outcomes. It was found from the N-gain values obtained in the experimental class (0.56) and the control class (0.39). Based on the analysis results, it was found that technology-based EIGEC had an effect, but the difference with the control class was insignificant (0.39). From the results of the T-test, it was found that technology-based EIGEC had an effect with a significance level for the post-test and an N-gain of 0.019 and 0.000. This increase is supported by the stages of each phase, where the technology-based EIGEC focuses on students' engagement abilities in the learning process. The engagement process was built at the initial meeting by focusing on student interest in learning. This interest can be packaged in a simple simulation before learning or by presenting something interesting that can increase student interest in learning. In addition, engagement can be presented in the form of stories or games that can focus students' attention at the beginning of learning.

It has a positive impact on supporting the continuity of learning in the classroom. After student engagement is formed, focus on students through problem recognition in the form of short questions or ask students to describe arguments related to what the teacher or lecturer says. It can open students' insights before the core learning begins. The most important keyword in technology-based EIGEC is a more focused engagement stage. In addition, using technology to support learning can be essential to supporting student engagement during the learning process. Using the right technology, or information and communication technology (ICT), can stimulate students to participate more actively during the learning process. As the findings from several journal reference state, using ICT in learning can increase interest in learning and learning outcomes; of course, these two correlates with student engagement during the learning process in class.

Based on the analysis of the weaknesses and characteristics of the PBL and TBL models, as well as the study of adaptive learning technology, a learning design development path named technology-based-EIGEC learning design was created. This design is here to simplify some of the phases in the problem-based and TBL models into a new phase. The technology-based EIGEC learning design is packaged in five stages: (1) Engagement, (2) introduction, (3) guidance, (4) execution, and (5) conclusion. Each phase is expected to foster student involvement, whose outcome is to have an impact on student learning outcomes.

CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

ETHICAL STATEMENT

REFERENCES

Ankiewicz, P., de Swardt, E., and De Vries, M. (2006). Some implications of the philosophy of technology for science, technology and society (STS) studies. *International Journal of Technology and Design Education*, 16, 117-141.

Barrows, H.S. (2000). *Problem-based Learning Applied to Medical Education*. Carbondale: Southern Illinois University Press.

Batdi, V. (2014). A meta-analysis study comparing problem based learning with traditional instruction. *Elektronic Journal of Social Science*, 13(15), 346-364.

Bednall, T.C., and Kehoe, E.J. (2009). *Effects of Self-Regulatory Instructional Aids on Self-Directed Study.* Kensington: UNSW Sydney.

Buchin, Z. (2018). Critical thinking skills across the semester in lecture-and team-based learning classes. *James Madison Undergraduate Research Journal*, 5(1), 21-32.

Burgess, A., Van Diggele, C., Roberts, C., and Mellis, C. (2020). Team-based learning: Design, facilitation and participation. *BMC Medical Education*, 20(Suppl 2), 461.

Burgess, A.W., Mcgregor, D.M., and Mellis, C.M. (2014). Applying established guidelines to team-based learning programs in medical schools: A systematic review. *Academic Medicine*, 89(4), 678-688.

Capon, N., and Kuhn, D. (2004). What's so good about problem-based learning? *Cognition and Instruction*, 22(1), 61-79.

Celik, P., Onder, F., and Silay, I. (2011). The effects of problem-based learning on the students' success in physics course. *Procedia-Social and Behavioral Sciences*, 28(1), 656-660.

Chad, P. (2012). The use of team-based learning as an approach to increased engagement and learning for marketing students: A case study. *Journal of Marketing Education*, 34(2), 128-139.

Chung, E.K., Rhee, J.A., and Baik, Y.H. (2009). The effect of team-based learning in medical ethics education. *Medical Teacher*, 31(11), 1013-1017.

Cónsul-Giribet, M. (2014). Strengths and weaknesses of problem based learning from the professional perspective of registered nurses. Revista Latino-Americana de Enfermagem *[Rev Latino-Am Nursing]*, 22(5), 724-730.

Cueli, M., González-castro, P., Krawec, J., Núñez, J.C., and González-Pienda, J.A. (2016). Hipatia: A hypermedia learning environment in mathematics. *Anales de Psicología [Psychology Analyses]*, 32(1), 98-105.

Falahah, F. (2006). Team-based learning; Sebagai salah satu pendekatan metoda pengajaran yang efektif [Team-based learning; As one approach effective teaching methods]. *Jurnal Teknodik [Technodic Journal]*, 10, 48-58.

Filgona, J., Sakiyo, J., Gwany, D.M., and Okoronka, A.U. (2020). Motivation in learning. *Asian Journal of Education and Social Studies*, 10(4), 16-37.

Fitria, Y., Yetti, R., Amini, R., and Eliyasni, R. (2019). Effectiveness of problem based learning for improving motivation and critical thinking skills. *International Journal of Innovation, Creativity and Change*, 5(4), 300-316.

Ghufron, M.A., and Ernawati, S. (2018). The strengths and weaknesses of cooperative learning and problem-based learning in EFL writing class: Teachers and students' perspectives. *International Journal of Instruction*, 11(4), 657-672.

Dolmans, D., and Gijbels, D. (2013). Research on problem-based learning: Future challenges. *Medical Education*, 47(2), 214-218.

Graaff, E.D. (2003). Characteristics of problem-based learning. *International*

Journal of Engineering Education, 19(5), 658-662.

Hartman, K.B., Moberg, C.R., and Lambert, J.M. (2013). Effectiveness of problem-based learning in introductory business courses. *Journal of Instructional Pedagogies*, 12, 1-3.

Hiebert, J., Morris, A.K., and Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education*, 58(1), 47-61.

Hmelo-Silver, C.E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, 16(3), 235-266.

Huljanag, M. (2021). Pentingnya proses evaluasi dalam pembelajaran di sekolah dasar [The importance of the evaluation process in elementary school learning]. *Educator: Directory of Elementary Education Journal*, 2(2), 164-180.

Hunt, D.P., Haidet, P., Coverdale, J.H., Richards, B. (2009). The effect of using team learning in an evidence-based medicine course for medical students. *Teaching and Learning in Medicine*, 15, 131-139.

Ifenthaler, D. (2013). Cognitive, metacognitive and motivational perspectives on preflection in self-regulated online learning. *Computers in Human Behavior*, 32(1),313-323.

Islam, Z., Islam, S.M., Hossen, F., Mahtab-ul-Islam, K., Hasan, M.R., and Karim, R. (2021). *Moringa oleifera* is a prominent source of nutrients with potential health benefits. *International Journal of Food Science*, 2021, 6627265.

Izumi, L. (2013). *Barbara Mitchell Centre for Improvement in Education Technology and Education: A Primer*. Vancouver: Fraser Institute.

Izzati, N. (2022). Pengaruh penerapan model pembelajaran carousel feedback untuk meningkatkan kemampuan berpikir kritis matematis dan sikap kreatif siswa [The Effect of implementing the carousel feedback learning model to improve students' critical mathematical thinking ability and creative attitude]. *(Jurnal Ilmiah Pendidikan Matematika) [Journal of Mathematics Education Scientific]*, 11(1), 13-25.

Jailani, J., Sugiman, S., and Apino, E. (2017). Implementing the problem-based learning in order to improve the students' HOTS and characters. *Jurnal Riset Pendidikan Matematika [Journal of Mathematics Education Research]*, 4(2), 247-259.

Koles, P.G., Stolfi, A., Borges, N.J., Nelson, S., and Parmelee, D.X. (2010). The impact of team-based learning on medical students' academic performance. *Academic Medicine*, 85(11), 1739-1745.

Lancellotti, M.P., and Boyd, T. (2008). The effects of team personality awareness exercises on team satisfaction and performance: The context of marketing course projects. *Journal of Marketing Education*, 30(3), 244-254.

Lee, E.O., and Waites, C.E. (2013). Infusing aging content across the curriculum: Innovations in baccalaureate social work education content across the curriculum. *Journal of Social Work Education*, 42(1), 49-66.

Lejk, M., and Wyvill, M. (2001). Peer assessment of contributions to a group project: A comparison of holistic and category-based approaches. *Assessment and Evaluation in Higher Education*, 26(1), 61-72.

Marin, L.M., and Halpern, D.F. (2011). Pedagogy for developing critical thinking in adolescents: Explicit instruction produces greatest gains. *Thinking Skills and Creativity*, 6(1), 1-13.

Martin, F., and Bolliger, D.U. (2018). Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. *Online Learning*, 22, 205-222.

Martin, F., Wang, C., and Sadaf, A. (2018). Student perception of helpfulness of facilitation strategies that enhance instructor presence, connectedness, engagement and learning in online courses. *The Internet and Higher Education*, 37, 52-65.

Mennenga, H.A., and Smyer, T. (2010). A model for easily incorporating team-based learning into nursing education. *International Journal of Nursing Education Scholarship*, 7(1), 1-14.

Michaelsen, L.K., and Sweet, M. (2008). *The Essential Elements of Team-based Learning*. Hoboken: Wiley Online Library.

Nursulistyo, E.D. (2021). Model team-based learning dan model problem-based learning secara daring berpengaruh terhadap kemampuan berpikir kritis siswa [Team-based learning models and problem-based learning models online affect students' critical thinking ability]. *Jurnal Mimbar Ilmu [Journal of the Sciences Forum]*, 26(1), 128-137.

Ocon, R. (2012). Teaching creative thinking using problem-based learning. In: *2012 ASEE Annual Conference and Exposition.* Washington, DC: American Society for Engineering Education, pp. 25-1245

Pardamean, B., Suparyanto, T., Cenggoro, T.W., Sudigyo, D. and Anugrahana, A. (2022). AI-based learning style prediction in online learning for primary education. *IEEE Access*, 10, 35725-35735.

Maretta, Y. (2016). Preparing prospective teachers in integrating science and local wisdom through practicing open inquiry. *Journal of Turkish Science Education*, 13(2), 3-14.

Pecore, J.L. (2013). Beyond beliefs: Teachers adapting problem-based learning to preexisting systems of practice. *Interdisciplinary Journal of Problem-based Learning*, 7, 1-28.

Rotgans, J.I., Rajalingam, P., Ferenczi, M.A., and Low-Beer, N. (2019). A students' model of team-based learning. *Health Professions Education*, 5(4), 294-302.

Rusiana, R. (2016). The constraints of the implementation of team-based learning In classroom action research class. *Journal Vision*, 5(2), 47-56.

Savery, J.R. (2015). Overview of problem-based learning: Definitions and distinctions. In: *Essential Readings in Problem-based Learning: Exploring and extending the legacy of Howard S. Barrows*. Vol. 9. United States: Purdue University Press, pp. 5-15.

Shih, J., Chuang, C., and Hwang, G. (2010). An inquiry-based mobile learning approach to enhancing social science learning effectiveness. *Educational Technology and Society*, 13(4), 50-62.

Siagan, M.V., Saragih, S., and Sinaga, B. (2019). Development of learning materials oriented on problem-based learning model to improve students' mathematical problem solving ability and metacognition ability. *International Electronic Journal of Mathematics Education*, 14(2), 331-340.

Torp, L., and Sage, S. (2002). *Problems as Possibilities: Problem-based Learning for K-12 Education.* 2nd ed. United States: ASCD.

Wagner, J.A. (1995). Studies of individualism-collectivism: Effects on cooperation in groups. *Academy of Management Journal*, 38(1), 152-173.

Watkins, K., Forge, N., Lewinson, T., Garner, B., Larance, D., Greenwald, L. (2018). Undergraduate social work students' perceptions of a team-based learning approach to exploring adult development. *Journal of Teaching in Social Work*, 38(2), 214-234.

Yew, E.H.J., and Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education*, 2, 75-79.

Yuretich, R.F., and Kanner, L.C. (2015). Examining the effectiveness of team-based learning (TBL) in different classroom settings. *Journal of Geoscience Education*, 63(1), 147-156.

Zhonggen, Y., and Wang, G. (2016). Academic achievements and satisfaction of the clicker-aided flipped business english writing class. *Journal of Educational Technology and Society*, 19(2), 298-312.