Application of generative learning in physics learning

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Abstract. This study aims: (1) to determine the application of generative learning in physics learning; (2) to determine the advantages of generative learning in the physics learning process; (3) to determine the constraints of generative learning in physics learning. The research method is literature study. Data was collected based on information obtained from various literature. Research shows that: (1) the application of generative learning in physics learning can improve learning outcomes, understanding of physics concepts, generic science skills, and able to reduce student misconceptions; (2) generative learning makes students more active, creative and critical in developing the knowledge obtained, discovering phenomena and solving problems. Meanwhile, the teacher will be skilled at organizing and understanding students' ideas; (3) The application of generative learning requires accuracy of methods and modification of strategies as well as careful planning and preparation. In addition, simulation is needed in a generative learning model to familiarize students. Teachers are required to be more observant and creative in expressing students' ideas. Generative learning is better applied to high school students.

1. Introduction
Science and technology are increasingly developing in the 21st century, resulting in a state of emergency for the knowledge community [1]. The existence of a scientific community group forces students to fulfill their specifications to become a scientific community. Education is the most influential factor in achieving these specifications. However, the development of the specification of the scientific community in the 21st century also has an impact on the quality of education, thus there is a need to encourage students to have expertise in Higher Order Thinking Skills (HOTS). Students must have 5 basic 21st century skills, namely critical thinking, problem solving, creativity and innovation, decision making, and metacognition [2].

Education is the most important part of individual life as an improvement in the quality of human resources [3]. Education is also a process in shaping individual attitudes and behavior through learning [4]. Education as an effort to improve learning outcomes can be seen from the efforts of the government and educational institutions in updating the curriculum, developing learning models and improving science process skills, especially physics [5].

Physics is a science that requires understanding and skills so that it requires variations in the learning process in the form of strategies and learning models that are appropriate and appropriate, so that the learning process can make students more active [6]. Physics studies natural phenomena that can be observed with the human senses, which contain facts, concepts, and principles based on existing phenomena and everything systematically [7]. Physics consists of several simple, complex, and abstract concepts. The concepts that exist are interconnected with one another so that it requires correct understanding and mastery [8]. Learning physics is one of the lessons that cause many problems because
students find it difficult to understand it, because physics studies symptoms through various processes known in the world of education is a scientific process that is created on the basis of a scientific attitude and the result is made as a scientific product [7]. This is in line with research on problems faced by students in the city of Singaraja in studying physics due to several factors, namely dense and non-contextual physics material, compulsion to memorize and count, and teachers' less optimal role in directing students [9]. Physics learning should use various learning models and in the student centered learning process so that it can make students more active [10]. This is in line with research on problems faced by students in the city of Singaraja in studying physics due to several factors, namely dense and non-contextual physics material, compulsion to memorize and count, and teachers' less optimal role in directing students [9]. Physics learning should use various learning models and in the student centered learning process so that it can make students more active [10]. This is in line with research on problems faced by students in the city of Singaraja in studying physics due to several factors, namely dense and non-contextual physics material, compulsion to memorize and count, and teachers' less optimal role in directing students [9]. Physics learning should use various learning models and in the student centered learning process so that it can make students more active [10].

The learning process in the classroom has two interdependent processes, namely the teaching and learning process, resulting in a learning atmosphere where students have an interest or interest in the learning process itself, because it is successful in learning activities [11]. Learning methods and models are needed to produce students who have an interest and interest in the learning process. The right learning methods and models can make it easier for students to understand the material provided by the teacher. The purpose of learning methods and models is to increase the level of success of teachers in the learning process and achieve goals or objectives such as creating an active classroom atmosphere so that it can have a good impact on students or in other words students can understand the material provided more easily [12]. Learning model that is conceptually mature and can be applied as well as a means to develop students' critical thinking is a generative learning model [13].

Generative learning model is a constructivist learning model where knowledge is created through student experiences and interactions [14]. In the generative learning model students are given the opportunity to express their opinions regarding the understanding of the given concept, then students are trained to respect the opinions of others, giving students the opportunity to construct the knowledge they already have so they can be more active, class atmosphere by comparing one opinion with another, and can make teachers more creative in directing students to construct existing concepts [15].

Based on the above introduction, the researcher is interested in conducting this research with the title "Application of Generative Learning in Physics Learning" which aims to find out the generative learning model, to know the application of the generative learning model in physics learning, and to find out the advantages and disadvantages of this model. Generative learning. In applying the generative learning model it is expected that it can be applied in further physics learning by combining different techniques.

2. Method
This research method is literature review. Literature review is an examination of various literatures on a topic that is carried out systematically. The data/information is then analyzed, evaluated, and combined into one discussion [16]. There are several steps in the literature review process. First, determine the topic of review by searching and identifying the discussion/problem of a case from various reference sources. Second, find and select articles according to the topic of discussion and then identify the information obtained in a structured manner. Third, classify from the beginning and classify the reviewed journals as an analysis of various types of related articles, determine the objectives and
methods applied to the research study and the results of the discussion. Fourth, punching the literature and directing the reader to be able to properly understand the literature review that has been done [17].

3. Results and Discussion

3.1. Generative learning in physics learning

Generative learning is a learning model first proposed by Osborne and Wittrock in 1985. This learning model is centered on integrating new knowledge with the initial knowledge students have in active learning [12]. The results of the integration show that generative learning is used to solve a problem, if the problem can be resolved properly then the new knowledge can be stored in memory [18].

Generative learning encourages students to construct their knowledge based on the results of their activities in classroom learning with active learning. The teacher is in charge of guiding students to find facts, concepts or principles based on their ideas. Student opinions are expressed freely to answer existing problems so that learning can be more optimal because they better understand the knowledge they previously had.

Wena divides generative learning into four stages. It consists of an exploration stage, a focus stage, a challenging stage, and an implementation stage. The exploration stage begins by giving students activities or assignments based on problems. The teacher guides students to solve these problems through learning topics related to everyday life so that they can explore their own initial ideas [19]. Student opinions are tested in the focusing stage by conducting experiments in the laboratory up to the initial hypothesis. At this stage students are trained to apply scientific processes. The teacher only acts as a facilitator.

The challenging stage begins by directing students to summarize the data obtained from previous activities in the worksheet. The teacher provides space for discussion so students can share and compare their ideas. At this stage, students are expected to be able to reconstruct their understanding. Then the new concept was tried out in implementation by giving various problems, both simple and complex, so that they could find the benefits of concept development. This stage can be done by giving homework or project assignments to students.

Generative learning makes the learning process more active in the classroom so that students are able to relate learning material to events and phenomena in everyday life, so that learning objectives can be achieved [20]. The following research seem in Table 1 uses generative learning:

| Writer's name         | Research Title                                                                 | Research result                                                                 |
|-----------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Appiah-Twumasi        | Generative learning strategy: physics intervention strategy for Improved Academic Achievement and motivation by gender | Generative learning strategies are able to increase student motivation and academic achievement [22]. |
| Syirlatifah, et al     | The application of generative learning models to improve the                   | Generative learning strategies are able to increase student activity and experience |
| Writer's name          | Research Title                                                                 | Research result                                                                                                                                                                                                 |
|-----------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hendriansyah, et al.  | The application of generative models in learning physics to overcome student learning outcomes and misconceptions | The implementation of lesson plans and test-based learning outcomes on vibration and wave material by 23 class VIII B students of SMP Muhammadiyah 1 Banjarmasin showed that the completeness of student learning outcomes increased from 33.33% in cycle I (good category) to 72.22% in cycle II (very good category). Misconceptions also decreased for all items in each cycle [24]. |
| Haris Rosdianto       | The effect of generative learning models on student cognitive domain learning outcomes in Newtonian law material | Referring to the multiple choice test answers from 25 students of class VIII E SMP VIII Singkawang, it shows that there is a significant effect of generative learning on student cognitive domain learning outcomes [25]. |
| Haris Rosdianto       | Student's Conceptual Understanding despite generative model in the topic "Light" | Based on the calculation results, it can be seen that tobs is less than -tt.v or -59.73 <= -2.093 which means that H0 is rejected and Ha is accepted, while the significance level is α = 0.05. This suggests that there is an effect of the generative learning model on students' conceptual understanding [7]. |
| Irwandani, et al.      | The effect of generative learning models on understanding the concepts of physics in the sound subject matter of students at MTs Al-Hikmah Bandar Lampung | The results of data analysis on the answers to the multiple choice test questions for all students in class VIIIA (experimental class) and class VIIID (control class) SMP Negeri 7 Bengkulu City on light material were 79.77 and 71.79, respectively. The t test shows the t value is greater than the t table, namely 6.29 > 1.997. And students' understanding of concepts increased by 35.51% [11]. |
| Dewi, et al            | Generative learning models assisted by virtual laboratory to improve mastery of Student Physics Concept | The results of the N-Gain test for 68 students at one of the Mataram high schools on the subject of Newton's general law, gravitational field, and Kepler's law were 70.1% (high category), 71.8% (high category), and 60.2%, respectively. % (medium category) indicates the effect of a virtual laboratory assisted generative learning model on students' mastery of physics concepts [26]. |
| Rameyanti Tampubolon   | The effect of generative learning models on the mastery of student learning concepts on vibration, wave, and sound | The results of one-party t-test calculations using SPSS 22.0 reveal that the significance value (0.000 <0.05) is at the level of α = 0.05 and dk = 72. This proves that... |
| Writer's name | Research Title | Research result |
|--------------|----------------|-----------------|
| Johar Maknun | The application of generative learning models in physics learning to improve vocational students' mastery of generic science concepts and skills | The results of the analysis of six indicators which include direct observation techniques, massive awareness of natural objects, proficiency in using symbolic language and making logical inferences to vocational students with topics of scale and unit and kinematics show an increase in student scores in the experimental group from 48.8 to 77.4 and the control group from 49.6 to 63.2. Generative learning affects vocational students' mastery of generic science concepts and skills [27]. |
| Tuada, et al. | The effect of the generative learning model with the guided teaching technique on science process skills. | Referring to the statistical test calculations, it can be seen that the value of \( t_{count} > t_{table} \) is 6.023 > 1.99 with a significant level of 0.05. Thus, the generative model with the guided teaching technique affects students' science process skills [15]. |
| Azizatuzzahro, et al | Generative learning model to improve science literacy competence on 10th Grade students of sciences Wahid Hasyim Senior High School on Temperature and Heat Topic | The results showed that the pretest and posttest scores of 25 students of class X SMA Wahid Hasyim on the topic of temperature and heat were 38.00 and 79.00. N-Gain in the experimental class and control class, respectively 0.66 and 0.48, are included in the moderate category. Meanwhile, the effective size value is 1.028. Thus, generative learning affects the improvement of students' scientific literacy [28]. |
| Yatmi, et al | The effect of the generative learning model on the critical thinking skills of physics in terms of students' initial knowledge | The average value of critical thinking skills of 24 students of class X MIA 3 (experimental class) and 25 students of class X MIA 4 (control class) of SMAN 1 Gunung Sari using genetic learning were 70.2 and 61.9. This proves that critical thinking in groups that apply generative learning is higher than groups with conventional learning [2]. |
| Septiara, et al. | Increasing soft skills through generative learning model in physics lesson eleven science 1 class at SMA Babussalam Pekan Baru | The results showed that the effectiveness of the generative learning model was in the low category, namely N-Gain of 0.46. In terms of the four aspects of soft skills, namely communication skills, problem solving, cooperation, and leadership, the N-Gain was obtained respectively 0.2 (very low category), 0.6 (high category) 0.4 (low |
Based on Table 1, it can be concluded that the application of generative learning can improve learning outcomes [21] [22] [7] [6], learning motivation [23], achievement index, academic achievement [23], conceptual understanding [7] [11], mastery of concepts [4] [11] [8] [24] [10], generic science skills [15] [25], scientific literacy [24], critical thinking skills [2] [26], soft skills [19], and reduce student misconceptions [22].

3.2. The advantages of generative learning

Based on the research results, generative learning has the following advantages:

| Writer's name            | Research Title                                                                 | Excellence                                                                                   |
|--------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Ratih Septiara, et al.   | Improving Soft Skills Through Generative Learning Models in Physics Lessons for Class XI MIPA 1 SMA Babussalam Pekanbaru. | Students' soft skills increase in communication skills, cooperation, problem solving and even leadership which are in the high category [19]. |
| Siti Nurkhayani, et al.  | Improving Class VIII Student Learning Outcomes at SMP Negeri 31 Banjarmasin on the subject of vibrations and waves through the application of generative learning. | The effectiveness of the application of generative learning model to improve student learning outcomes is included in the effective category [6]. |
| Nur Rosuli               | Integrated Remedial Learning by Applying Generative Learning Models to Change Student Misconceptions about Business and Energy Concepts. | Generative learning can change students' misunderstanding of concepts into correct concepts as they should be [27]. |
| Ibnu Hendriansyah        | Application of Generative Models in Learning Physics to Overcome Student Learning Outcomes and Misconceptions. | Generative learning if applied will improve student learning outcomes and reduce misconceptions on the material being taught [22]. |
| Rasydah Nur Tuada       | The Effect of Generative Learning Models with Guided Teaching Techniques on Science Process Skills. | Generative learning models have better science process skills than conventional learning models [15]. |
| KD. A. Permana Dewi, et al. | The Effect of Generative Learning Model on Critical Thinking Ability of Class V Students in Cluster VIII, Buleleng Regency | Generative learning affects or improves students' critical thinking skills [13]. |

Generative learning makes students more creative and critical in developing previously acquired knowledge, this learning model allows students to receive information actively that focuses on students' ability to construct interpretations of previous information to find new conclusions. Thus, students can
review previous concepts well, and are also able to find phenomena and solve problems. This trains them to work and focus more independently. Sutarman revealed that presenting the results, discussing, and answering teacher questions was evidence of student activeness in using generative learning [28].

Generative learning provides space for students to compare their own opinions with others. Also generative learning gives them the opportunity to express the benefits of their opinion. So, they will appreciate other ideas.

Misconceptions often occur due to students' understanding of conceptions that are not in line with scientific concepts. The application of generative learning provides opportunities for students to pay more attention to initial concepts. Thus, students will be aware of misconceptions and make corrections that occur when using generative learning. Generative learning requires teachers to develop concepts, principles and techniques. Thus, this learning model builds teachers who are more skilled in understanding the views and organizing students.

3.3. Constraints on the application of generative learning
The steps in implementing generative learning must be considered as best as possible to support accommodation and assimilation in the minds of students. Based on the research results above, generative learning has problems, as follows:

| Writer's name     | Research Title                                                                 | Obstacles                                                                                     |
|-------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Ratih Septiara, et al. | Improving Soft Skills Through Generative Learning Models in Physics Lessons for Class XI MIPA 1 SMA Babussalam Pekanbaru. | It requires the skills of teachers to be more creative in making and designing teaching materials so that the enthusiasm of students in solving problems is better and the time management required for generative learning [19]. Generative learning must pay attention to things that can bring out accommodation and assimilation in students' minds[27]. |
| Nur Rosuli, et al. | Integrated Remedial Learning by Applying a Generative Learning Model to Change Student Misconceptions about Business and Energy Concepts | generative learning before its implementation requires careful planning and preparation [26]. |
| Ziadatul Fatimah  | The influence of the Generative Learning Model with Guided Teaching Techniques on the ability of Class XI Physics Problem Solving | There is a need for simulations to get used to the stages of the generative learning model, generative learning is better done in small groups so that groups are more active, teacher creativity is needed to explore students' ideas [11]. |
| Irwandani          | The Influence of Generative Learning Model on Understanding of Physics Concepts in the Voice of Students at MTs Al-Hikmah Bandar Lampung |                                                                                              |

The difficulty of students with learning experiences is because they are not accustomed to being given the responsibility of using worksheets, so generative learning takes longer. Therefore, generative learning methods and strategies need to be modified so that they can be used efficiently to maximize
learning outcomes. Simulations are also needed to familiarize students. In addition, the application of generative learning that is centered on student activity is better for high school students. Experiment and animation media are needed in generative learning to support student interest. This reduces student misunderstanding and helps the teacher to interact and guide students’ ideas optimally.

4. Conclusions
Based on the research that has been done, the following conclusions are drawn: 1) The application of generative learning in physics learning can improve student learning outcomes, understanding of physics concepts, generic science skills, and able to reduce student misconceptions; 2) The advantages of the generative learning model in physics learning include students being more active creatively and critically in developing the knowledge obtained, being able to find phenomena and solving problems, being trained to respect other people's opinions, and being able to realize and correct existing misperceptions. Meanwhile, the teacher will be more skilled in organizing and understanding students' ideas; 3) Generative learning constraints that require proper planning and preparation, experiments and animation media are needed to support the learning process, and students need to get used to using this model through simulation. In addition, generative learning is more suitable for high school students.

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