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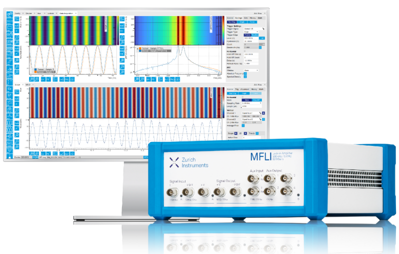

Developing a Hypothetical Learning Trajectory in STEM Lessons on Earthquake Themes

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Abstract. This study aims to develop a hypothetical learning trajectory in Science, Technology, Engineering, and Mathematics (STEM) lessons on earthquake themes for sixth grade (elementary school) students. The research applied a qualitative descriptive method with data collection techniques through peer teaching of pre-service elementary schools' teacher in a teacher professional education program. A total of 35 pre-service student teachers from the Elementary School Teacher Education (ESTE) program were divided into 7 peer-teaching groups with 7 students acting as teachers and 28 students acting as sixth-grade students. Each group consists of 1 teacher and 4 students, and they conduct STEM lessons on earthquake themes. An FGD was conducted after to discuss the hypothetical learning trajectory that developed during the learning process shown by each group. The resulting HLT design consists of objectives, activities, and predictions of student responses and teacher reactions in dealing with each existing student response. Activities consist of the development of scientific concepts, such as the concept of earthquakes, tools regarding the use of artificial technology that assists the disaster mitigation process, engineering ideas concerning earthquake-resistant housing designs, and mathematics concepts such as circles and three-dimensional curved shapes. This HLT is effective in increasing understanding of the materials, and it is applicable to use as a reference for teachers to conduct STEM lessons on earthquake themes.

INTRODUCTION

Hypothetical Learning Trajectory (HLT) is a learning trajectory that is expected to occur in the learning process, either through students' thinking processes or other variables that occur during learning. HLT consists of objectives, activities, and predictions of how students' thinking and understanding will develop during learning activities [1]. Teachers use HLT to design learning processes that improve student learning outcomes [2]. HLT will assist teachers in using models, strategies, and learning media to the fullest. In addition, assessments that are following students' thinking stages also require HLT to achieve learning that is consistent with students' thinking patterns and characteristics. Teachers as facilitators in the learning process have an important role in developing learning activities to achieve the learning objectives. Therefore, teachers and prospective teachers need to design and develop HLT as a part of lesson planning.

Prospective teachers in Indonesia must take Pre-service Teacher Professional Education (PTPE) as part of their certification. Pre-service PTPE is a professional education program to produce a new generation of Indonesian teachers who are passionate, professional, committed to being role models, honor their profession, and are lifelong learners. Pre-service PTPE is provided for undergraduate or applied science graduates from both educational and non-educational majors to obtain a teaching certification in their respective fields [3]. One of the programs that provide pre-service PTPEs is Elementary School Teacher Education (ESTE) program which prepares professional teachers to teach in elementary schools.

Elementary school is the first entry educational level that individuals attend in formally [4]. Elementary schools remain an influential stage in the learning development process. Elementary schools are the initial means of instilling knowledge, concepts, and values regarding the environment and life [5]. Learning in schools today must be in accordance with 21st-century learning. Science and technology continuously evolve in today's 21st century, and constant development requires certain skills. These 21st-century skills include collaboration skills, creativity, critical thinking, communication, problem-solving, analytical and algorithmic thinking skills, and similar skills [6]. One way to revolutionize 21st-century learning is by implementing the Science, Technology, Engineering, and Mathematics (STEM) learning approach.

The STEM learning approach integrates science, technology, engineering, and mathematics and focuses on problem-solving processes in everyday life. The STEM learning approach shows students that the use of concepts and principles in mathematics, science, technology, and engineering is integrated to develop products that provide real-

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life benefits [7]. These four components form a single unit that is related to one another to create active, innovative, and applicable learning. The purpose of developing the STEM learning approach is to prepare students with skills that are supportive and relevant to life in the 21st century as well as the Industrial Revolution 4.0 era that Indonesia is currently facing [8]. These skills are applied to paradigms such as STEM education. STEM education is not a separate subject but a paradigm of scientific disciplines such as science and mathematics mixed with technology and engineering-based design applications [9].

The development of the 4.0 Industrial Revolution era requires the education system to be innovative so that students can master various knowledge and skills based on the level of student development [10]. The development of STEM poses the answer to these problems. In addition, the results of this study are beneficial from scientific and practical perspectives. From a scientific point of view, this study provides references on the STEM learning process in elementary schools where there are only a few, while from the practical perspective, it produces learning trajectories in STEM that elementary school teachers can use to achieve learning goals.

METHODS

This research is qualitative descriptive research. Qualitative descriptive research is used to interpret a phenomena that occurs [11]. The data collection technique was in the form of peer teaching videos, student worksheets, and assessment results. The sampling technique used was purposive sampling. Purposive sampling is a sampling technique with certain considerations [11]. The purposive sample in this study was based on the research focus on Pre-service Teacher Professional Education (PTPE) at a private university in Bandung, Indonesia who studied teaching principles and assessment courses in elementary schools. Before becoming a PTPE, prospective students go through three stages of selection, namely stage one administrative and essay selection, stage two substantive tests to measure content mastery and basic literacy and numeracy skills, stage three interviews to explore competence, personality and motivation.

The subjects in this study were 35 PTPE students majoring in elementary school teacher education who were divided into 7 peer teaching groups with 7 teachers and 28 students. Each group consisted of 1 student who became a teacher and 4 students who acted as students. Before peer teaching is carried out, students are given training regarding the learning tools that will be implemented, given direction regarding the use of the STEM approach in learning, and pedagogical materials. The aim is to develop HLT from the peer teaching of pre-service students through interactive analysis of what is happening in class and its implementation. The HLT developed from each student peer-teaching group was analyzed using the Forum Group Discussion (FGD) method. This method is used as a form of tool to find in-depth information about the topics discussed using in-depth discussions in groups [12]. FGD is carried out by students presenting and giving each other opinions regarding HLT that is developing in each group's learning. The results of the FGD were written in note form and analyzed using the content analysis method. The FGD method in this study aims to obtain as much data interaction as possible from the results of peer teaching groups to provide an in-depth elaboration from various aspects regarding the development of STEM learning HLT on earthquake themes. The integration of STEM in the earthquake themes is shown in Table 1 below.

TABLE 1. HLT STEM on Earthquake Themes

Science	**Technology**
1. Use the earthquake themes to perform earthquake disaster mitigation and self-rescue procedures. 2. Present products and processes on simple, environmentally friendly technology	1. Use the Internet to find information related to earthquakes. 2. Identify artificial technologies that can help the process of building earthquake-resistant houses
Engineering	**Mathematics**
1. Investigate various earthquake-resistant house designs 2. Design a prototype and test it 3. Redesign to get the ideal earthquake-resistant house design	1. Analyze the elements of the circle 2. Solve contextual problems related to the surface area of three-dimensional curved shapes

FINDINGS AND DISCUSSION

Overview of the STEM Learning Process on the Earthquake Theme

An overview of the STEM learning process on the earthquake theme in this research was carried out in two meetings by seven groups of peer teaching teacher candidates. The first meeting was about the concept of an earthquake related to the center point of the circle and the elements of the circle. The second meeting was about mitigating earthquake disasters by designing earthquake-resistant houses. Project exploration and STEM learning were evident in the second meeting after the concept was explained in the first meeting. Each peer-teaching group consists of 1 student who acts as a teacher and 4 students who play the role of sixth-grade students. Before peer teaching, students who played the role of teachers designed their learning materials. The learning materials consist of Learning Implementation Plans (LIP), Student Worksheets (SW), assessment sheets, learning media, and teaching materials. Peer teaching was conducted in separate places as shown in Figure 1 below.

(a) (b)

FIGURE 1. Peer teaching of STEM Learning to the preservice students at the Teacher Profession Education Program. (a) Peer teaching of Group 1, (b) Peer teaching of Group 2

The first activity is the explanation of the concept of an earthquake, including an explanation of the epicenter and hypocenter of the earthquake. The epicenter point is the recorded earthquake point on the surface of the earth and the hypocenter point is the recorded earthquake point below the earth's surface [13]. These points form a circle, and the epicenter point is related to the center point of the circle studied in mathematics. Students identify the elements of a circle from the concept of an earthquake. Furthermore, students describe how earthquakes occur and the vibrations generated by these earthquakes on the surface of the earth. The teacher directs students to make a circle from the earthquake vibrations generated on the earth's surface. The purpose of this first activity is to introduce students to the concept of the center point in an earthquake's epicenter and hypocenter. The following is a snippet of a learning video transcript regarding the epicenter and hypocenter of earthquakes.

Teacher: The hypocentre will form a shockwave at the epicentre. Well, these waves in the hypocentre will form a circle. Now, here are the circles. You can see from this picture. What is this point? (*the teacher draws an earthquake wave on the board*)
Student: Epicentre point. (*Students answer in unison*)
Teacher: Ok, the closer someone is to the epicentre, the earthquake will become…
Student: Noticeable.
Teacher: You can feel it or it gets stronger. For example, here are Jaka and Dani, and their distances to the epicentre are the same. So, the vibrations that Jaka and Dani feel are the same or different? (*students write Jaka and Dani's names on the blackboard on the earth waves that the teacher made*)
Student: It's the same. (*students answer in unison*)

The teacher draws an illustration of the epicenter and hypocenter of the earthquake in the form of circles and relates it to the earthquake vibrations if the students are in the same position. The goal is for students to understand that the closer someone is to the epicenter of an earthquake, the stronger the earthquake feels. Therefore, students can deduce the difference in potential damage caused by an earthquake from the point of view of the proximity of the surface to the epicenter.

Earthquakes are natural disasters with no warning signs like others, so there are steps needed to reduce the risk of earthquakes in the form of earthquake disaster mitigation [14]. Students design an earthquake disaster mitigation by first being given a stimulus in the form of an introduction to technological concepts. The purpose of the second activity is for students to mention technologies related to earthquakes. The teacher directs students that technology is not only limited to objects related to computers or the Internet but all the means to provide the tools needed for human survival. One of the tools that can assist in solving problems related to earthquake disaster management is the tools used to help design earthquake-resistant houses. Students and teachers discuss these tools with the end product of creating an earthquake-resistant house design.

In the third activity, the teacher asks several questions about what can be done to reduce the risk of earthquake impacts, the student's prior knowledge of earthquake-resistant houses, and what a good house design looks like to make an earthquake-proof house. The teacher asks these questions one by one and allows students to discuss them. Several answers emerged from the students, ranging from building a sturdy building, a house that was not too high, to the shapes of houses such as cubes or cylinders or half a ball. These answers become a stimulus for students to test what kind of buildings are earthquake resistant in the next activity.

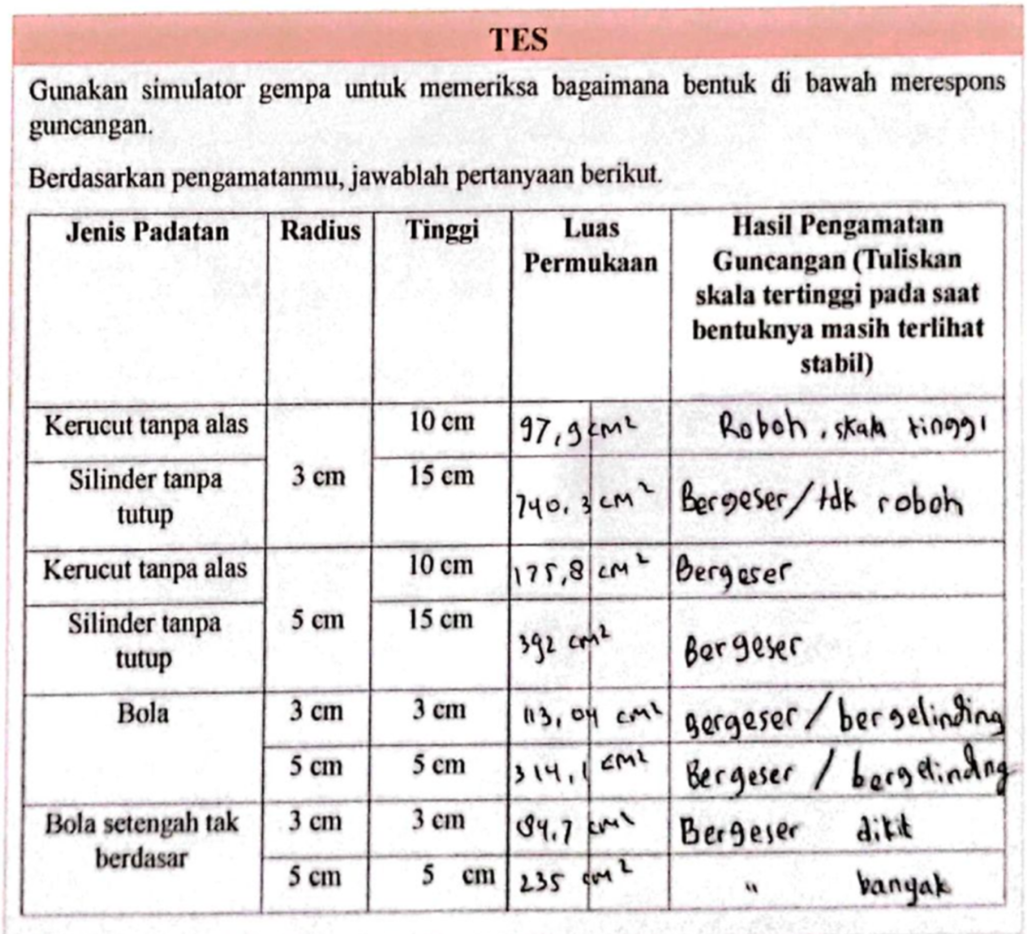
The fourth activity is for students to design earthquake-resistant houses with some criteria, including building designs that use effective and efficient materials, designs that are strong enough to withstand heavy loads, designs that are strong enough to provide wider space for shelter, withstand shocks, and designs that provide more space for nature. Some students answered by drawing a design of an ideal house with these criteria, but others were still confused about aspects of building design that use efficient materials. The teacher instructs students to discuss with group members and discuss it later with the whole class.

The fifth activity is when students design shapes from various sizes of cones, cylinders, and balls to simulate earthquake resistance buildings. In addition to variations in shape, students also show variations in the sizes of each shape by first calculating the area of each shape. The types of spatial structures are tested with an earthquake simulator and students determine which buildings are more resistant to earthquakes. Figure 2 below shows the students performing the simulation.

FIGURE 2. Earthquake Resistant House Building Simulation

The sixth activity is related to the question of which building criteria are the strongest to withstand shocks and loads and what building design criteria can provide more space for shelter. During this mathematics learning in the context of earthquake-resistant houses, students must understand the concept of flat shapes and geometric shapes, how to calculate the area of geometric shapes, and possess arithmetic skills and an understanding of parallel geometry. This is per Van Hiele's theory which argues that the level of students' geometric thinking happens sequentially in five stages: visualization, analysis, abstraction (informal deduction), deduction, and rigor [15]. At the visualization stage students recognize geometric shapes by looking at their shape; the analysis stage occurs when students understand the properties of these shapes; the abstraction stage happens when students understand the relationship between one geometric shape and another; the deduction stage allows students to conclude specific things, and the students' rigor stage proves the principles of the shape [16]. In addition, the STEM learning stages also align with the learning phases of Van Hiele's theory, namely (1) the information phase, in which the teacher asks questions and students answer, while also performing activities related to the theme studied following the students' thinking stage, (2) the orientation phase occurs when students explore the topic through tools that have been carefully assigned by the teacher. (3)

Explanation phase happens when students express their emerging views about the observed structure based on their previous experience, (4) Free orientation phase emerges when students face more complex tasks in the form of tasks that require many steps, tasks that are completed in many ways, and open-ended tasks, (5) Integration phase is when students review and summarize what they have learned. At the end of this fifth phase, students reach a new stage of thinking, in which students are ready to repeat the learning phases at the previous stage [17]. The test results are shown in Figure 3 below.



TES

Gunakan simulator gempa untuk memeriksa bagaimana bentuk di bawah merespons guncangan.

Berdasarkan pengamatanmu, jawablah pertanyaan berikut.

Jenis Padatan	Radius	Tinggi	Luas Permukaan	Hasil Pengamatan Guncangan (Tuliskan skala tertinggi pada saat bentuknya masih terlihat stabil)
Kerucut tanpa alas	3 cm	10 cm	97,9 cm²	Roboh, skala tinggi
Silinder tanpa tutup		15 cm	740,3 cm²	Bergeser/tdk roboh
Kerucut tanpa alas	5 cm	10 cm	175,8 cm²	Bergeser
Silinder tanpa tutup		15 cm	392 cm²	Bergeser
Bola	3 cm	3 cm	113,04 cm²	Bergeser/bergelinding
	5 cm	5 cm	314,1 cm²	Bergeser/bergelinding
Bola setengah tak berdasar	3 cm	3 cm	84,7 cm²	Bergeser dikit
	5 cm	5 cm	235 cm²	" banyak

TEST

Use the earthquake simulator to determine how each shape below responds to the quake.

Based on your observation, complete the blanks.

Types of Solid	Radius	Height	Surface Area	Observation Result on the Quake (Write the highest scale when the form remains stable)
Open cone	3 cm	10 cm	97,9 cm2	collapsed/ high scale
Open cylinder		15 cm	740,3 cm2	shifted / not collapsed
Open cone	5 cm	10 cm	175,8 cm2	shifted
Open cylinder		15 cm	392 cm2	shifted
Sphere	3 cm	3 cm	113,04 cm2	shifted/toppled over
	5 cm	5 cm	314,1 cm2	shifted/toppled over
Hollow hemisphere	3 cm	3 cm	84,7 cm2	slightly shifted
	5 cm	5 cm	235 cm2	very much shifted

FIGURE 3. Building Test Results Earthquake Resistant House Simulation

Based on the test results above, students concluded that an earthquake-resistant house can be made in the form of a hemisphere because when there is a shock, the building does not collapse and only shifts slightly. This is proven by the existence of a dome house in Yogjakarta. The dome house has a semicircular shape that is rounded like an igloo like a typical Eskimo house. The uniqueness of this earthquake-resistant building is that it has a dome-like shape. Dome houses in Indonesia are found in the Yogyakarta area, which is also a tourist destination area. The earthquake-resistant building was built because of the 2006 Yogyakarta earthquake, and this earthquake-resistant building technology is applied to withstand future quakes. The key to a dome house as an earthquake-resistant building is minimizing the number of corners as well as connections between buildings, using lightweight materials such as styrofoam so that it can withstand earthquake shocks, designing safe and comfortable structures so that earthquake hazards can be minimized, and having doors and windows for smooth air circulation [18]. Figure 4 below shows one of the dome house designs found in Yogjakarta.

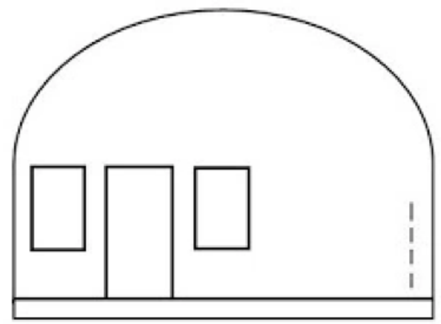


FIGURE 4. Design of a Dome House in Yogjakarta

Once the students concluded the design of the earthquake-resistant house, they worked on assessment questions related to the geometrical area of one of the dome house designs and calculate its volume. Therefore, students can apply their mathematical knowledge in everyday life in the context of this earthquake-resistant house.

Preparation of HLT

The results of this study are that the HLT design shows an occurrence of a learning trajectory in STEM lessons on earthquake themes. The learning activities conducted by students and teachers and their responses are provided in Table 2 below.

TABLE 2. HLT of STEM Learning on Earthquake Themes

No.	Classroom Activity	Student Response Prediction	Teacher Response
1.	Students identify the epicenter of an earthquake and the concept of an earthquake.	• The epicenter of an earthquake is illustrated as the center point of a circle • Students described their personal experiences with an earthquake • Students could not identify the epicenter of the earthquake	• Stimulate by showing videos of potential earthquake occurrence • Draw the epicenter and hypocenter • Draw earthquake circles on the surface • Draw an example of two people who are on the same circle of epicenter waves
2.	Students discuss tools that solve problems related to earthquake disaster management and then discuss how to create these tools	• Objects related to computers and the internet. • Machine-related technology. • Students mentioned the tools used to help design earthquake-resistant houses • Students did not answer.	• Stimulate students by asking whether other simple tools can also be considered as technology, unlike all modern technology students mentioned. • The teacher confirms that all those tools are part of technology. Then the teacher asks why those tools are considered technology. • Stimulate students with examples of technology in everyday life.

No.	Classroom Activity	Student Response Prediction	Teacher Response
3.	The teacher and students discuss the kind of houses that can withstand the impact of the earthquake.	• Build a sturdy building. • Houses that are too high are not for earthquake-prone areas. • The building must be cube-shaped. • The building must be cylindrical or hemispherical. • It is possible that students do not know how to reduce the risk of earthquakes.	• The teacher asks students to discuss so those who do not know the answer can discuss first, then bring the results of the discussion in class and provide opportunities for several students to answer. • Provide several pictures of houses with different designs as references for students' answers. • Look for reading material regarding earthquake-resistant house design.
4.	The teacher and students determine the criteria for completing a successful earthquake-resistant house design.	• Students may find it difficult to determine aspects of building design that use effective materials. • Students may have difficulty determining the design aspects of buildings that are strong enough to withstand heavy loads. • Students may find it difficult to decide on aspects of building design to provide more space for living quarters.	• The teacher asks students to discuss beforehand with their peers. • The teacher shares their ideas with the whole class and allows several students to respond. • Open the website of the national disaster management agency (https://bnpb.go.id) to find out the criteria for earthquake-resistant house design. • Shows several pictures of houses that managed not to collapse after the earthquake occurred.
5.	Students design shapes with certain variations based on the student worksheet.	• Students may find it difficult to design hemispherical buildings. • Students have difficulty designing cylinders. • Students have difficulty determining the radius of the base of a solid object.	• Teacher can help students by instructing them to make circles that they can then put together first. • The teacher asks, what if we bend the piece of paper? • The teacher asks, What would the shape of the base look like? The goal is to direct students to create a circle/round shape.
6.	Students discuss, make observations, and experiment, then present the results of the discussion.	• There may be students who have difficulty explaining the results of their discussions • Students will likely recommend only cylindrical shapes. • Chances are students will only recommend the hemispherical shape. • Students may recommend shapes that are cylindrical and half-spherical.	• The teacher allows students to discuss with their peers first. • The teacher shares the results of the discussion with the class and allows several students to respond. • The teacher asks students why they chose these shapes. • The teacher connects the results of students' experiments, namely recommendations for earthquake-resistant houses with houses that have successfully withstood earthquakes in real life.

HLT in Table 2 above refers to the conceptual learning trajectory level which consists of 1) situational level, students are in a specific situational context, namely in the students' identify the epicenter of an earthquake and the concept of an earthquake; 2) Reference level, models and strategies refer to the situation described in the problem, namely in the activities of students discuss tools that solve problems related to earthquake disaster management and then discuss how to create these tools, activities of the teacher and students discuss the kind of houses that can withstand the impact of the earthquake, and the activities of the teacher and students determine the criteria for completing a successful earthquake-resistant house design; 3) general level, mathematics focus on strategy assignments that refer to context, namely the students' activity of designing shapes with certain variations based on the student worksheet; and 4) formal level, working with conventional procedures and notation, namely in the activities of students discuss, make observations, and experiments, then present the results of the discussion [19].

The HLT developed in Table 2 above is a learning implementation process that is guided by an instrument in a learning design that can be described and improved during the ongoing research process [20]. The HLT is finally summarized in a table containing a set of activities that students must undertake, the expected mental activities, and the role of the STEM learning approach on the earthquake theme. Teachers play a role in determining learning variations according to each student's learning trajectory [21]. The following are the things that underlie the construction of HLT, namely (1) HLT is carried out to increase students' understanding of knowledge; (2) As a vehicle for planning the learning of mathematical concepts; (3) Providing tools to promote mathematics learning concepts; and (4) It is hypothetical so this process is uncertain, and teachers are regularly involved in modifying every aspect of HLT [22]. Thus, the HLT can be further developed through observing students during learning activities, and it is hoped that a set of actualized learning trajectories will be obtained [23].

Integration of STEM Learning in HLT

The integration of STEM learning in HLT begins with science learning, namely getting to know areas in Indonesia that have the potential to experience earthquakes, understanding the term Richter scale, understanding the center point of a circle through the meaning of the epicenter and hypocenter of an earthquake, and understanding the elements of a circle through the context of natural disasters. This activity can be carried out for all class VI students both in Indonesia and outside Indonesia, especially in countries or regions that have the potential for earthquakes. Students can identify areas that have the potential for earthquakes by observing earthquake risk maps, one of which is Indonesia, which is located on three earth plates that are always actively moving. These plates are the Eurasian, Pacific, and Indo-Australian Plates. This plate movement produces pressure which leads to tectonic earthquakes [24]. Apart from that, Indonesia is also in the ring of fire, which is the most active volcanic chain in the world that stretches along the Pacific Plate [25]. Magma activity, which usually occurs before a volcano erupts, will trigger volcanic earthquakes. Volcanic earthquake vibrations are usually limited to the area where the volcano is located.

Next, students study circle material in mathematics in the context of the hypocenter and epicenter of an earthquake. The hypocenter is the center of an earthquake or can be said to be the epicenter of an earthquake, while the epicenter is an earthquake that occurs on the earth's surface [26]. The epicenter can be said to be a wave propagating from the hypocenter. When the hypocenter produces an earthquake point, the earthquake has circular waves. These circular waves become the context for learning mathematics about circles. Therefore, when two people are in the same circle, the earthquake is felt the same.

The next activity, related to technology and engineering, is that students learn about disaster mitigation. Disaster mitigation is action to reduce disaster risks, both through physical development and raising awareness of the ability to face disaster threats [27]. These actions include, for example, increasing disaster knowledge, preparing standby bags, and strengthening house buildings. In this lesson, students learn how to prepare a house to be earthquake resistant. Students discuss and create earthquake-resistant house designs with various building shapes. The technology used in disaster mitigation is using the internet to search for information regarding the shape of earthquake-resistant houses and identifying artificial technology that can help the process of building earthquake-resistant houses. Next, students design several forms of buildings that are earthquake resistant. Designing earthquake-resistant building shapes is related to engineering and is also related to building materials in mathematics lessons. Students create spatial shapes including open cones, open cylinders, spheres, and hollow hemispheres of various sizes. These spatial structures are tested using an earthquake simulator so that students can determine which types of buildings are earthquake-resistant from the simulation results. In general, several basic principles of earthquake-resistant buildings can be used as a reference or concept for building houses in earthquake-prone areas, including simple and symmetrical plans and building structures, with the building height not exceeding four times the width of the building, light volume, built in a monolith, and with a strong foundation or building substructure [28]. One example of the anti-seismic house design recommended by the National Disaster Mitigation Agency (NDMA) is the dome house.

Overall, this design research begins by posing a problem, followed by concept analysis and finding the right solution to solve the problem. The proposed solution is concretely realized in student activities as defined by HLT. This research collectively addresses using and assessing hypothetical learning trajectories (HLT) in STEM learning integration. HLT helps teachers in planning mathematics teaching and developing coherent and effective teaching materials [29]. Mathematical modeling in HLT to help students understand the sequence of mathematics learning [30]. Overall, this research highlights the benefits and effectiveness of using HLT in STEM learning trajectories.

Limitations

For this study, we identified two limitations. First, the small sample size limits the validity of the study population. A larger sample will produce greater population validity in the learning trajectory that students go through in learning. Second, the specific context of earthquake-resist house design can also be considered a limitation. Other research should be conducted to see whether the integration of other engineering specialties also contributes to the learning of earthquake-resistant house criteria. In the end, this project provides an opportunity for follow-up, which can provide information and expand our knowledge about the theme of earthquakes as an effort to teach students to be aware of earthquakes and carry out disaster mitigation.

Implications

The results of this research have several implications for teachers and educational researchers who want to provide experience in implementing STEM learning, especially on the theme of earthquakes. Our research results support HLT designs centered on integrating earthquake and STEM content domain knowledge. This HLT design is based on a conceptual framework that emphasizes the need for a well-structured knowledge base and the use of concept mapping as a tool to structure teacher efforts in dealing with student learning flows.

CONCLUSION

The hypothetical learning trajectory in STEM lessons on earthquake themes was developed from the results of peer-teaching of the pre-service PTPE students by looking at the responses and anticipation of student responses in learning. The HLT that has been developed is based on the results of the FGDs from each group and summarizes all the activities that occur from each peer teaching result. The HLT of STEM lesson on earthquake themes consists of six main activities, starting from the introduction of the concept of earthquakes and the epicenter of the earthquake, the use of technology for earthquake-resistant houses, variables that can affect earthquake-resistant houses, designing the ideal shape of a building for earthquake-resistant houses, testing the building structure, and concluding the building criteria for earthquake-resistant houses. Based on this process, students can understand the ideal criteria for an earthquake-resistant house, which is a half-circle shape like one of the houses in Yogjakarta called dome houses. Therefore, the developed HLT design meets the criteria for a systematic teaching sequence for STEM learning on earthquake themes.

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