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ETHNO-RME: A CONTEXTUAL APPROACH TO TEACHING ALGEBRA CONCEPT USING ICT

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Abstract: Development of technology cannot be avoided, so it will give an impact on all aspects of life, including the field of education. Learning using technology can make learning more effective and efficient. However, technological developments also have a negative impact on culture, because access to other cultures is easier. This makes it difficult to preserve one's own culture. Apart from that, technology also helps the process of learning mathematics, which is known to be abstract, to become more realistic with visualization and a more real approach. This research aims to analyze the Etno-RME approach to learning basic algebra concepts with the help of ICT. The approach used in this research is fenomenology qualitative. The data in this research was obtained using observation and interview techniques with class VII students who applied basic algebra concept learning using the Etno-RME approach. The data analysis used in this research uses the Miles & Huberman data analysis technique with stages of data collection, data reduction, data presentation, and drawing conclusions. The results of the research show that the application of mathematics learning uses a contextual approach based on Borobudur temple culture. The learning process is designed in accordance with the learning obstacles experienced by students before, during, and after the implementation of instruction. Designed learning can create more effective and innovative learning situations to improve student's conceptual understanding.

Keywords: basic algebra, ICT, ethnomathematics, realistic mathematics learning

Introduction

Most math content certainly involves algebraic elements. Algebra is identical to the language of mathematics which involves symbols, tables, letters and graphs in its learning (Stacey & Macgregor, 2000a). Algebra is quite important mathematics learning content because algebra can be thought of as opening material for mathematics with advanced understanding (Jacobson, 2000; Jupri et al., 2014). However, algebra makes the statement that mathematics is an abstract science and is becoming more popular. Students have difficulty formulating and understanding equations in algebra to explain information that is given in word form and then studied using symbols that must be manipulated to get a solution. (Stacey & Macgregor, 2000a).

There are many problems in learning algebra at school, starting from understanding algebraic expressions and applying them to arithmetic operations, understanding the meaning of an equation, to understanding the variables themselves (Jupri et al., 2014). Understanding variables is actually a trivial and fundamental problem in algebra. However, if this understanding is not strengthened, it will be difficult to learn algebra at a higher level, because as previously emphasized, algebra is synonymous with symbols and letters. The symbols and letters in question generally indicate the identity of variables in algebra. At the basic level, students often lack the ability to solve algebraic problems, especially when brought into real contexts, both procedurally and conditionally (Jacobson, 2000). In short, the reason why algebra is often considered difficult and difficult material to learn and teach is the difficulty in using algebraic notation. (Egodawatte, 2009; Şengül & Erdoğan, 2014). Even though in a learning context, introduction to algebra is basic material that should be easy to learn. However, often in learning

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practice, this is not paid enough attention. In fact, the cause of students experiencing difficulties in learning algebra generally lies in students' difficulties in understanding the basic logic of problem solving in algebra (Stacey & Macgregor, 2000b).

Basically, research related to basic algebra has been carried out by many researchers on an international scale. The research was conducted on 120 Sri Lankan secondary school students in grades 9 and 10 from three schools. One of the basic problems is "Amanda is 4 years older than Diana. The sum of their ages is 28 years. How old is Amanda?". As many as 49.4% of students made mistakes in transforming contextual problems into algebraic language. Students generally make mistakes because they are not able to identify when symbols and symbols are used (Egodawatte, 2009). This shows that almost half of the students still do not understand the context and conceptual problems related to algebra.

Research conducted by Candace Walkington examined 70 grade 9 students. One of the problems presented in this research was, "Some rental cars have cell phone facilities. For a rental car making a call from a cell phone is $1.25/minute with an initial fee of $2.50. If the call costs $20. How many minutes does the call last?" As many as 50% of the sample did not understand the meaning of the problem given. Students do not even understand the meaning and context of the problems given (Walkington et al., 2012).

The basic algebra problems that students have in learning mathematics show initial indications that students will experience higher difficulties if faced with unusual problems. This is because all these assessments focus on students' ability to solve problems. Students are said to be able to solve problems when they are able to solve new problems or situations using the knowledge they have acquired (Setiawan & Lestari, 2014). Students will be able to solve more complex problems if they have adequate basic knowledge as a foundation of knowledge. However, in reality students still make mistakes and experience difficulties in solving unusual problems, so students still make mistakes in understanding questions, in transformations in using irrelevant formulas or procedures (Y. B. Setiawan et al., 2018). In fact, there are still many students who are unable to know what procedures to use when solving unusual problems.

Research conducted by Gunawardena Egodawatte in 2009. Research entitled Is Algebra Really Difficult for All Student is research that aims to show students' difficulties in learning algebra. The research results show that students do experience difficulties in algebra material, because learning algebra requires a longer abstraction process. This process is because algebra itself involves arranging symbols. Often in algebra results in multiple representations. This research also explains student errors in algebra which result in difficulties in analyzing the basic differences between arithmetic and algebra. Difficulties in learning algebra are caused by various factors, including the basic abilities possessed by students. Apart from that, the teaching approach used tends to be inappropriate in introducing algebra which is known to be abstract. (Egodawatte, 2009). There are several studies that support this research. The research entitled A Study on the Elementary Students Perceptions of Algebra which was carried out in 2013 aimed to evaluate the algebra abilities of grade 6 elementary school students. With a quantitative approach, the results showed that 6th grade elementary school students still had low algebra skills, especially in the analysis, procedural and introduction stages of algebra problems. (Şengül &

Erdoğan, 2014). The research results show that the majority of students have a poor perception of algebra. This is because algebra is too abstract and involves symbols that are difficult to understand and variable concepts that students cannot understand either simply or in depth.

Students' difficulties in learning algebra remain diverse. Numerous obstacles are encountered by students when studying basic algebra, ranging from fundamental issues in algebra learning, such as performing algebraic operations, manipulating algebraic expressions, to understanding context-based algebra problems (N. S. Utami et al., 2023; Wojongan & Jupri, 2023; Ying et al., 2020). The most prominent issue, which often leads to other difficulties, is that algebra is taught in an overly abstract manner, making it challenging for students to solve both abstract problems and those presented in real-life contexts. To address these various difficulties, this study was conducted. The purpose of this research is to design algebra instruction based on the Ethno-Realistic Mathematics Education (Ethno-RME) approach. Ethno-RME is a learning approach that utilizes contextual situations rooted in local culture. In line with this research aim, an in-depth analysis was carried out to investigate the learning obstacles experienced by students in the process of learning basic algebra.

The contextual approach (Contextual Teaching and Learning/CTL) is an approach to learning that connects learning with students' real life contexts. The goal is to make learning more relevant, meaningful, and easy to understand by relating new knowledge to experiences, situations, or problems that students face in everyday life (E. B. Johnson, 2002). The contextual approach involves students discovering the concepts being studied by connecting the material with the knowledge they have and students' experiences in everyday life. Through a contextual approach, students are expected to be able to solve problems, especially problems in real life (Selvianiresa & Prabawanto, 2017). Therefore, through a contextual approach it is hoped that it will be able to increase students' understanding and involvement by connecting mathematical concepts with relevant real-life contexts (Wijaya, 2015).

Contextual learning in mathematics learning follows certain patterns/rules or is known as the Realistic Mathematics Education Approach. Through RME, mathematics must be seen as an activity based on students' reality and experiences. This approach aims to make mathematics learning more meaningful and relevant for students by connecting it to contextual situations (Freudenthal, 2002; Gravemeijer & Terwel, 2000). The RME approach is able to provide students with a deep understanding in terms of connecting mathematical concepts with contextual situations. Apart from that, the RME approach tends to be able to have a positive influence on student learning outcomes when compared to students who use conventional approaches (Ardiyani et al., 2018; Haji, 2019; Laurens et al., 2018; Muslimin et al., 2020). The RME approach is able to provide better results in learning mathematics, especially algebra (Kusumaningsih et al., 2018). However, in reality teachers still have difficulty translating and applying RME principles in learning, making learning more difficult. The wrong application of the RME approach only affects the provision of contextual problems as a final evaluation of mathematics learning. Apart from that, the difficulty in finding contextual situations that can be used as learning content is also a problem in learning that applies a contextual approach (Kubra Guler & Kubra Güler, 2018).

Ethnomathematics is one context that can be used to carry out a contextual approach. Through ethnomathematics, mathematics is not only seen as an aspect that is quantitative and focuses on numbers, but is also seen as something that is culturally neutral (Veselin Jungic, n.d.). In simple terms, ethnomathematics can be seen as mathematics in a cultural element (Irma Risdiyanti and Rully Charitas Indra Prahmana, 2020). Culture is meant not only as a physical element, but also in the form of social relationships within it (Veselin Jungic, n.d.). Therefore, the ethno-RME approach is a contextual approach using a social/local context.

Borobudur Temple is a cultural context that has elements of mathematics in it. Many mathematical concepts can be found in Borobudur temple objects, including mathematical patterns in the form of building structures. Apart from that, the building concept can also be part of the flat and spatial construction context (Utami et al., 2020). If observed directly it would take quite a long time, because the Borobudur temple area has a surface area of 21893 m^2 (Borobudur, 2017). Therefore, it is important to use technology as a form of application in terms of visualization.

Technological development is a form of globalization development which provides various positive impacts if used properly. Maximum use of technology can help facilitate the process of visualizing areas that have never even been visited. In other words, technology will make it easier to introduce culture to all levels of society (Niculescu, n.d.; Younes & Al-Zoubi, 2015). Through the use of technology, access to find out about the essence and visualization of your culture will become easier (Younes & Al-Zoubi, 2015). Therefore, it is important to use technology wisely, especially to increase learning effectiveness (Lewin et al., 2019). One form of technological development that can be used as a starting point in cultural exploration is Google Earth.

Google Earth is a page from Google that shows the use of very sophisticated technology to explore the world. Google earth displays the shape of the earth seen far away and other detailed things on the earth with 3D features (Google, n.d.). Apart from visualization using Google Earth, this site can also explore related information data. Therefore, Google Earth can be used as a medium for learning in schools. The use of Google Earth in learning at school can improve students' cognitive abilities in exploring and understanding learning (Alfatikh et al., 2020; Thankachan & Franklin, 2013). Using Google Earth in class can improve students' abilities in using technology and sorting information (Alfatikh et al., 2020).

Ethno-RME approach can enhance the effectiveness of mathematics learning. Ethno-RME has been shown to improve students' learning outcomes in mathematics. Moreover, this approach supports the development of students' mathematical communication skills, conceptual understanding, problem-solving abilities, and representational competence (Muhammad et al., 2025). Through the use of locally contextualized learning, students can more easily grasp mathematical concepts, particularly in algebra instruction. This approach has demonstrated a positive impact on students' learning outcomes in algebra (Nurnaningsih et al., 2024). These benefits are further supported by the integration of technology in algebra learning, both as a tool to facilitate the process of mathematization and as a medium for exploring students' responses and the contextual elements embedded in algebraic problems (Alghiffari et al., 2024; Nurnaningsih et al., 2024).

Several previous studies only explained algebra learning carried out using a realistic, general-based approach. Although there are many impacts obtained from implementing realistic learning in mathematics. A realistic mathematical approach can improve students' problem solving abilities and provide a deeper conceptual understanding. Based on testing on algebra learning designs using the RME approach in schools, it is able to develop students' reasoning and problem solving abilities because they have a deep conceptual understanding. This learning design is able to provide better learning outcomes when compared to learning outcomes using traditional methods (Asmara et al., 2019; Ekowati et al., 2021). Apart from that, when compared with other approaches such as individual learning which focuses on understanding the material, the RME approach also provides better learning outcomes in algebra learning (Palinussa, 2020).

The use of Google Earth in mathematics learning is still rarely done. Generally in previous research, Google Earth was used in geography learning which emphasized position and location. However, the use of Google Earth in learning can provide good results in the learning process. The learning outcomes of students who use Google Earth in learning are better than conventional learning without using technology (ICT). By using Google Earth in learning, it is easier for students to visualize and can explore more broadly and deeply (Thankachan & Franklin, 2013). Therefore, students who learn by utilizing technology in the form of Google Earth have higher motivation and enthusiasm to start learning (Alfatikh et al., 2020). Therefore, the use of Google Earth in mathematics learning can be used to start locally based realistic learning (Etno-RME). It is hoped that the combination of these two elements can realize the true essence of mathematics learning, namely fun learning.

Materials and Methods

This research was conducted using a qualitative approach. The qualitative approach is a research approach that emphasizes in-depth explanations of social phenomena (Hancock et al., 2009). Research with a qualitative approach will study a phenomenon in an open way, without prior expectations (B. R. Johnson & Christensen, 2014). This research is included in didactical design research. This didactic design research will design the learning process based on the problems/learning obstacles experienced by students in learning algebra concepts. Didactical design research contains plans, structures, and investigative strategies prepared to obtain answers to research questions related to learning algebraic concepts and controlling variance (Pandey & Pandey, 2015). This method includes three phases: developing an initial design by conducting prospective analysis, conducting teaching experiments, and conducting retrospective analysis (Suryadi, 2011, 2013).

The first stage carried out a prospective analysis by collecting students' difficulties for algebra concept topics and relevant previous studies (Suryadi, 2013). Prospective analysis is carried out by giving tests to students who have studied algebra concepts and conducting semi-structured interviews with mathematics subject teachers. The students used were 6 class VIII students with different abilities. Based on the test results, three main difficulties in this topic can be identified, namely didactical obstacle, epistemological obstacle, And ontogenic obstacle (Suryadi, 2013). In the second phase, a trial was carried out on the learning design that had been designed by adapting to the students' difficulties that had been previously encountered. At this stage, it was carried out on 12 class VII students. The students involved in the implementation of the designed instructional plan were selected based on their prior knowledge. The students were categorized into three ability levels: high, medium, and low. The design trial was conducted in Grade VII, as the concept of algebra is introduced at this level according to the Indonesian curriculum. The trial aimed to identify learning obstacles encountered by students during the instructional process. These obstacles were observed through students' responses during the implementation of the pre-designed Hypothetical Learning Trajectory (HLT). Furthermore, interviews were conducted with students to gain deeper insights into their perspectives on the contextual elements used in the HLT. In the third phase, a focused group discussion among members of the research team was conducted to revise the design developed in the previous step. This discussion aimed to produce a finalized and ready-to-use instructional sequence for the teaching experiment. The combination of these steps constitutes a form of data triangulation to ensure the validity of the research findings.

Results and Discussion

Learning barriers obtained based on metapedadidactic analysis include didactical obstacle, epistemological obstacle, And ontogenic obstacle. Ontogenic obstacle is a type of learning obstacle experienced by students and originates from the students themselves (Suryadi, 2013). When giving tests, it can be seen that students' ability does not know the basic definitions of algebraic elements such as variables, coefficients and constants. In fact, only a few of the samples could name the terms in a linear equation $2x + 6 = 4$. When the problem is presented in the form of an everyday problem, the sample is unable to solve and determine the variables, coefficients and constants in the problem. Students cannot present the problems given in algebraic language. This shows that there are difficulties that originate from the students' own abilities. This learning obstacle also indicates the type of challenge students face due to their limited understanding of the foundational concepts of the lesson. This type of difficulty falls under the category of epistemological obstacle (Suryadi, 2013).

When asked questions about the learning system implemented at the institution, students stated that learning was carried out as usual and traditionally. The teacher conveys the material to be studied and immediately provides examples of problems. This shows a form of difficulty that comes from outside the student (didactical osbtacle) in the form of delivering the material being taught (Suryadi, 2013). Based on these conditions, it can be said that the learning that takes place in schools still shows a conventional learning system. After conducting an interview with the mathematics subject teacher, the teacher said that in the learning process, the most important thing is that students are able to solve questions that are identical to the final assessment carried out. Basically, students are only required to be able to solve the questions given in the assessment at the end of the semester. Planting a concept will only waste time because it requires quite a long time. It is better for students to be given a similar problem directly so that students become familiar with the problem. This actually provides time efficiency and some of the remaining time can be used to continue practicing.

Based on the initial observations above, teachers' assumptions like that cannot be blamed. Basically, a learning system that provides examples of similar problems will help students learn more easily. This will provide a less complex thought process and make learning mathematics easier (Castro-Alonso, 2021). However, researchers feel that this is not suitable for use in continuous mathematics learning. There are several materials that require a perfect process of instilling concepts so that students are able to deal with material at a higher level, one of which is algebra concept material. Apart from that, all female students have very minimal knowledge regarding Indonesian culture.

Based on the learning obstacles encountered by students in algebra learning, a Hypothetical Learning Trajectory (HLT) was developed for this instructional design. The HLT was designed using the Ethno-Realistic Mathematics Education (Ethno-RME) approach and incorporated the use of educational technology. In the context of this learning, aspects contained in the culture of Borobudur Temple are used as starting points in learning algebraic concepts. This section discusses how students gain an introduction to the concept of elements in algebra. The activity that took place was recognizing the elements in the Borobudur temple by exploring using Google Earth. The aspect that is of main concern is the stupa at Borobudur Temple.

Problem 1: Observing the Base Area of the Stupa

Pay attention to the shape of the base of the Borobudur Temple stupa below. If the area of the base of the small stupa is, and the area of the base of the large stupa is, then determine:

a. The base area of 3 small stupas

b. The base area is 12 small stupas

c. The base area of the stupa is large with 2 small stupas

d. The base area of the stupa is large with 4 small stupas

In problem 1, students are expected to be able to determine how wide the bases of several stupas at Borobudur temple are. n this problem, students are required to analyze the given task presented in a real-life context. They are expected to perform multiplication and addition operations within various contextual situations. In the first two questions, students are asked to calculate the total base area, assuming all stupas are of the same type. However, in the following two questions, students are required to be more careful in calculating the base area, as there are two different elements involved, making it impossible to solve the problems using a single calculation step. Through the problems given, several possibilities will emerge learning trajectory. Students will determine the total area of the stupa by adding them together, or by doing multiplication. Based on the results of the teaching experiment, almost all students calculated the entire area of the stupa base (Problems 1.a and 1.b) using addition. No students calculated the total area of the stupa using the multiplication method. This shows that the multiplication ability of class VII students is still limited. Therefore, the researcher provides the inverse problem of problems 1.a and 1.b. As for problem 1.c. and 1.d. Students are able to solve these problems using the addition method. This condition indicates that the students' initial analytical abilities are fairly good. They were able to solve the given problems using an intuitive approach, which suggests that their foundational knowledge is sufficiently well-developed.

Problem 2. Observing the Base Area of the Stupa

If the area of the base of the small stupa is, then the area of several stupa bases is . So how many stupas are there which shows the area of the base of the area?

In this problem, students are presented with a reversed-type task. They are first given the context of determining the total base area of several stupas, and then are required to calculate the number of stupas. Based on the students' work, eight students understood that the problem could be solved using division; among them, two students successfully solved the problem, while six others reported not being familiar with division. Meanwhile, four students solved the problem using incorrect methods, as shown in Figure 1. The students stated that the problem was not different from the previously given problems. This indicates that the students' initial ability to comprehend the problem was already problematic, resulting in difficulties when presented with unfamiliar problem types. This condition is categorized as an epistemological obstacle caused by students' limited mastery of the material (Suryadi, 2013). Furthermore, this activity also reveals that students' conceptual understanding of multiplication and division operations is inadequate. This reflects a conceptual ontogenetic learning obstacle experienced by the students (Suryadi, 2013). Such learning difficulties are evident in students' responses, which demonstrate how their previous learning experiences, particularly concerning basic arithmetic operations, influence their problem-solving processes.

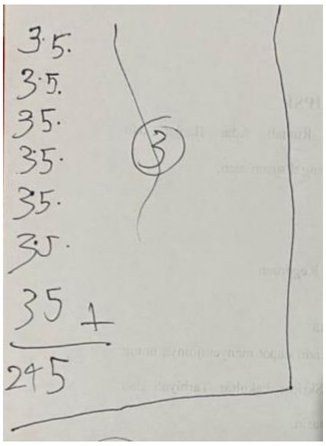

Figure 1: Student's Answer of the Problem 2

Furthermore, by making the stupa a high context, it can bring out students' ability to observe the resulting patterns. This can be seen from the following problems:

Problem 3. Observing the Structure of Stupa

Pay attention to the following scheme of the Borobudur temple stupa!

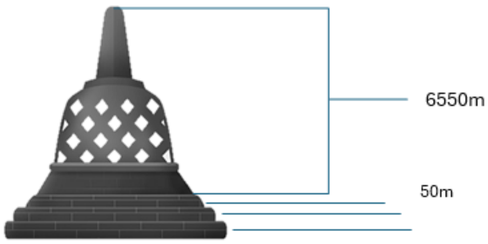

Figure 2: The Structure of Stupa's height

a. Determine the height of the stupa from the top to the 1st level stairs

b. Determine the height of the stupa from the top to the 2nd level stairs

c. Determine the height of the stupa from the top to the 3rd level stairs

This problem represents a stage of abstraction in basic algebra learning. Through the given problems, students are able to observe emerging patterns and engage in the process of abstraction to identify the concepts of variables, coefficients, and constants. However, during the teaching experiment phase, students still solved the problems using an intuitive approach. Students solve the problem by adding the heights one by one. However, there was 1 student who solved using the multiplication method. Regarding this condition, the teacher directs students to differentiate and show that the problem given can be solved using the multiplication method. However, all students were unable to read the pattern in the problem, but were helped by the teacher to name the elements that changed in the problem. Through this, teachers can introduce algebra elements in the form of coefficients, variables and constants.

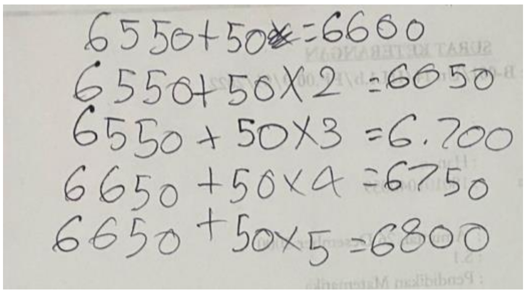

Figure 3: Student's Answer of the Problem 3

These three issues include learning objectives, learning activities, and expectations of students' learning processes, which guide the description of the learning sequence above, called a hypothetical learning trajectory (HLT). (Clements & Sharma, 2009; Simon, 2014; Suryadi, 2011, 2013). Learning trajectories designed with the ethno-RME concept can provide students with deep understanding abilities in learning algebra concepts by reducing learning obstacles experienced by students (Asmara et al., 2019; Ekowati et al., 2021; Laurens et al., 2018).

The process of abstraction in introducing algebraic concepts is crucial to ensure that students develop a deep understanding of basic algebra. Through a well-developed abstraction process, students will be able to solve various problems, including both typical and non-routine problems. In learning algebraic concepts, particularly the introduction of algebraic elements, the use of contextual situations is essential. The designed learning trajectory can begin by considering students' prior learning experiences, such as arithmetic operations. With a solid foundation in arithmetic skills, students will find it easier to engage in the learning process. It is important to provide non-routine problems involving integer arithmetic operations within the context of local culture. Subsequently, students are guided to observe patterns that emerge from each activity performed. The form of the learning trajectory for basic algebra learning using a local cultural context based on Borobudur temple culture is illustrated in this picture:

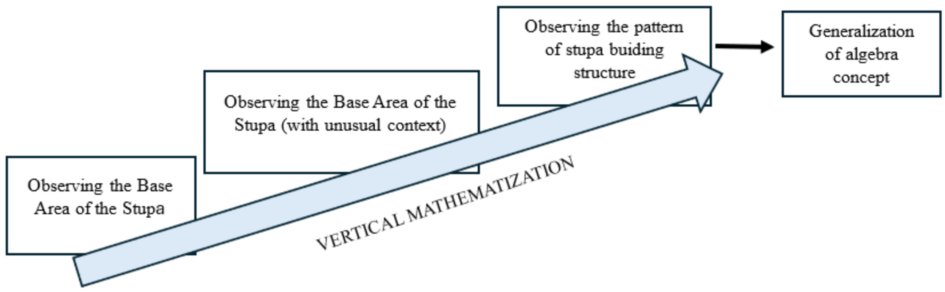

Figure 4: Hypothetical Learning Trajectory of Learning Algebra

The learning sequence experienced by students in the introduction of algebraic concepts must be thoroughly detailed. This aims to provide students with a deep conceptual understanding. The Ethno-Realistic Mathematics Education (Ethno-RME) approach offers a solution in this learning process by helping students grasp concepts through the use of locally based contexts (Alghiffari et al., 2024; Muhammad et al., 2025; Nurnaningsih et al., 2024). Ethno-RME is more effective for concept introduction because it enables students to better imagine the context due to its proximity to their own experiences. Furthermore, through Ethno-RME, students perceive mathematics as more relevant to themselves (Shahidayanti et al., 2024). Therefore, this approach is expected to enhance students' conceptual understanding in algebra learning. In addition, by integrating technology such as Google Earth, cultural contexts that are otherwise difficult to visualize can be explored more extensively. Google Earth facilitates students' exploration of local contexts (Alfatikh et al., 2020; Thankachan & Franklin, 2013).

Conclusion

The learning sequence for algebraic concepts can start from introducing simple addition of algebraic expressions for addition, subtraction, and multiplication of algebraic expressions. This sequence begins by using elements from the Borobudur temple obtained by exploration using Google Earth. Through this, students will discover the essence of learning mathematics, namely gaining a deep understanding. Furthermore, by using a similar case, it can be used as a starting point for exploring students' arithmetic operations skills in the form of multiplication and division operations. Then, this is done by generating elements whose values will not change and combining them with elements whose values change as something attached to them changes. Through HLT, students will have the ability to solve problems in contextual situations with in-depth conceptual understanding.

For future research, several aspects need to be considered for further improvement of this study as recommended. This study was conducted as a trial with a small class consisting of only 12 seventh-grade students with varying abilities. Additionally, the cultural context used was limited to the Borobudur temple culture. More specific suggestions, such as exploring the scalability of the approach in other cultural contexts or testing its effectiveness across different mathematical topics, would be beneficial.

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