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by Jurnal Kreano

Identification of Representation Ability in the Topic of Space Analytical Geometry for Student in Higher Education

Abstract

The objective of this research is to expose the representation skills of future mathematics educators by delving into the content of Space Analytical Geometry and identifying potential enhancements. The type of research is design research involving 38 students of the Mathematics Department, FMIPA UNM. The research instruments used are Lesson Plans and e-tasks. The e-Task is the instrument combining the LMS Syam-OK and Gdrive for collecting the outputs of these activities. The results suggest that 1) students' representation approaches depend on their knowledge level, with broader knowledge leading to diverse presentation information. 2) The complexity of given questions influences the development of students' representation methods. 3) An analytical approach is employed for specific problems requiring visual elements in the solution. The implications call for adjustments through the presentation of challenging problems that impact the flexibility of methods and the variety of exercise materials supporting the enhancement of representation abilities.

Keywords: Representation Ability; Space Analytical Geometry

Abstrak

Penelitian ini bertujuan untuk mengungkap keterampilan representasi mahasiswa calon guru matematika dengan mendalami materi Geometri Analitis Ruang dan mengidentifikasi peningkatan yang dapat dilakukan. Jenis penelitian ini adalah penelitian desain yang melibatkan 38 mahasiswa Departemen Matematika, FMIPA UNM. Instrumen penelitian yang digunakan adalah Rencana Pelajaran dan e-Task. E-Task merupakan instrumen yang menggabungkan LMS Syam-OK dan Gdrive untuk mengumpulkan hasil kegiatan tersebut. Hasil penelitian menunjukkan bahwa 1) pendekatan representasi mahasiswa bergantung pada tingkat pengetahuan mereka, semakin luas pengetahuan menghasilkan informasi presentasi yang lebih beragam. 2) Kompleksitas pertanyaan memengaruhi perkembangan metode representasi mahasiswa. 3) Pendekatan analitis digunakan untuk masalah tertentu yang memerlukan elemen visual dalam solusinya. Implikasinya menuntut penyesuaian melalui penyajian masalah yang menantang, yang memengaruhi fleksibilitas metode dan ragam materi latihan untuk mendukung peningkatan keterampilan representasi.

INTRODUCTION

Representation ability is an ability that is not only important for students (Kohl & Finkelstein, 2005; Surya et al., 2013) (Nasrullah et al., 2021) especially in learning mathematics, but also this ability is important for students in higher education because they become a central issue in mathematics teaching (Elia & Gagatsis in (Gervasoni, 2006). This ability requires concepts and uses them to communicate the user's understanding of a given problem with mathematical ideas (De Cock, 2012), This is because unlike other scientific domains, a construct in mathematics is only accessible through its semiotic representation and in addition, one semiotic representation by itself cannot lead to an understanding of the mathematical object it represents (Duval, 2006). In addition to increasing the user's mathematical knowledge, for example solving arithmetic problems (Elia & Gagatsis in Gervasoni, 2006)), the placement of the right representation will support mathematical problem solving on the right track where applying these representations requires different strategies (Kohl & Finkelstein, 2005). Not infrequently students fail to construct the expected problem-solving caused by failure at the representation stage (Surya et al., 2013). Therefore, teachers need to provide opportunities for students to solve mathematical problems as well as mathematical understanding and representation (Minarni et al., 2016), it is even hoped that the student's representation ability should have reached the best level of the specified category.

However, (Dewi & Sopiany, 2017)

suggest that students still have low representational abilities to create problem situations based on the data or representations given. Of course, this will have an impact on students' lack of skills in generating ideas, asking questions, and responding to other people's questions or opinions (Widakdo, 2017). Research (Minarni et al., 2016) reveals that students' ability to represent essay questions is still relatively low. In addition, Sari et al. (2018) examined student errors in mathematical representation tests. The results showed that students made mistakes in solving problems involving arithmetic symbols, namely concepts related to characters, and applying other mathematical concepts. Thus, students' mathematical representation skills still require special attention and action to be improved (Saputri & Kamsurya, 2020).

This low ability shows the need for attention because students use representation as a tool to support their mathematical understanding by constructing abstract ideas into concrete ideas using logical thinking, representation is something that represents something else (Duval, 2006). Because representation is a sign or configuration of signs, characters, or objects that mark and configure to represent, describe, or represent something other than itself. So that it will support students to learn and communicate, connecting mathematical concepts to solve problems in each project. Representation as one of the standard processes shows that the process of learning mathematics in schools must develop students' representational abilities. Mathematical representation is the ability to represent a mathematical problem in the form of symbols, images, manipulative objects, and other mathematical ideas (Farokhah et al., 2019).

This problem does not need to occur for prospective teacher students because it will facilitate students to learn mathematics later. For this reason, when becoming a teacher, the representation ability has developed very well so that it does not experience difficulties in directing students to mobilize these abilities. This avoids what happened to teachers in South Sumatra and Bangka Belitung where 48.4% were able to correctly represent symbolic representations into graphic representations (Hapizah et al., 2019). Undoubtedly, teachers should teach students in such a way that students can solve mathematical problems as well as mathematical understanding and representation (Minarni et al., 2016). One of the challenges they will face is that students can use symbolic representations to find solutions to problems, and then they can perform mathematical operations based on known data from the problem. However, this ability is not well developed for all students, most students still have difficulty in using symbolic representations to solve problems correctly. This has the impact of making it difficult for students to solve problems involving mathematical expressions or symbolic representations (Farokhah et al., 2019) (Ruslan et al., 2017).

For this reason, the transposition of students to think as teacher candidates needs to be trained as suggested by (Utami et al., 2019) (Nasrullah et al., 2017). It is possible that most of the students experienced the same as students where they still have low mathematical representation skills, and have difficulty understanding problems and writing equations correctly. This is because students are not used to solving problems in the form of visual, verbal, and symbolic representations. Therefore, prospective teachers must be trained in students' mathematical representation skills by applying the multiple representation learning model which is using transpositive work to reach they can reach the point that knowledge transposed is itself bettered (Chevallard & Bosch, 2020). Farokhah et al. (2019) in their research, the results showed that the obstacles experienced by students in representing a mathematical problem were triggered by the limited ability to visualize a problem in the form of other mathematical models, the limitations of students in connecting the knowledge they already had with the form of representation. a mathematical problem, and limitations in applying mathematical concepts so that they cannot be represented correctly. Another factor that also affects students' representational abilities is student flexibility. Thus, a prospective teacher who will facilitate students in learning activities needs to improve the way in visualizing, connecting, and applying mathematical concepts flexibly so that the process of interpreting and constructing knowledge based on the given problem can develop properly.

Therefore, this study works to explore the extent to which student-teacher candidates progress in developing their representational abilities to solve spatial analytic geometry problems.

METHOD

To carry out this research, the initial activity carried out was to design learning activities that prospective teacher students would participate in. Their activities for this course contain the following materials, 1) Three-Dimensional Space, 2) Point Distances in Three-Dimensional Space, 3) Coordinates of Points in Cartesian, Tube, and Spherical Spaces, and 4) Vectors in Three-Dimensional Space. To observe the progress of students' learning in this study, observations were made not only when they responded to problems given in class, but also through tasks that were collected virtually. Assignments are collected by students through LMS Syam-OK and connected to GDrive, known as e-Task (Nasrullah & Baharman, 2018). Through this e-Task, we can easily make virtual observations and facilitate students to collect assignments anytime and anywhere. The research subjects involved were 38 people from students of the mathematics education study program majoring in mathematics, FMIPA UNM. Therefore, this research is supported by a research instrument in the form of a compilation of student assignments stored on the G-Drive.

In the learning activity design process, the learning environment is formed by containing three entities, namely learning objects, learning services, and sub-environments (Koper & Olivier, 2004). The learning objects in this case are entities used in learning, such as books, websites, and other learning resources. Some learning resources other than the books used, for example brilliant, topper, cuemath, and others. Then the learning services used are in the form of services needed for learning, such as learning resource services, communication services, and monitoring services. This learning service tool involves Google Drive and LMS Syam-OK. While in the activity design, there are 3 components to be considered, namely the name of the activity, the goal, and the output. Overall, this process is shown in the following diagram.

Figure 1 shows how to provide lecture activities. In lecture activities, several stages are carried out starting from 1) Preparation, a stage where the activity begins with preparing all lecture needs including Semester Learning Plans (RPS), Lecture Materials, and Publication Media (for example, e-Task). 2) Input Lecture Materials, the next stage where lecture materials are presented through publication media and prepared to be distributed to students. 3) Learning Interaction, at this stage there are 2 main processes, namely the provision and acquisition of material. The provision of material meant in this case is that students are given material prepared by the teacher in various forms, both written, presented through an electronic LMS, and others. When material input is carried out, the expected activities are oriented toward practice activities, experiments, and case/problem-solving. Then acquisition can mean that students actively get various materials that are determined and prepared for lecture activities either through the LMS or in the e-Task system. This acquisition activity is directed as part of the learning process or solving cases/ problems. Therefore, the targeted outputs are activities and outcomes related to exercises, experiments, case-solving, or problem-solving. The sub-environment in lecture activities is designed in such a way that it supports the expected learning process. To achieve the expected target as shown in the picture, in the learning process 4 topics of lecture activities are placed. These four topics are directed at providing learning opportunities for students so that the expected representational abilities and information support the target of this research.

To support the trustworthiness of this research, four criteria of the approach used are credibility, transferability, dependability, and confirmability (Stahl & King, 2020). For the credibility criteria, the consistency of the research findings is shown by comparing the artifacts of analytic geometry space learning with the observations in the classroom. For transferability, this process takes place by observing the tendencies for the 4 given activity contexts. The response of students in the

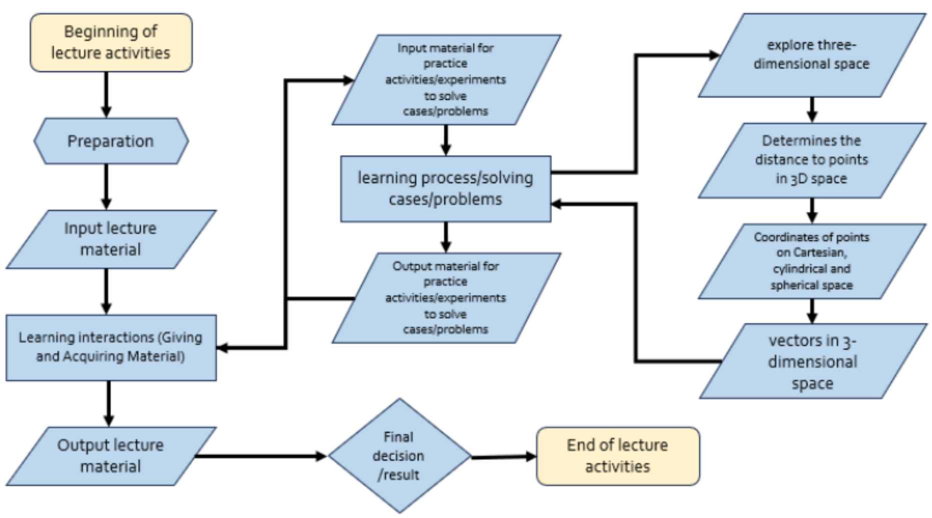


Figure 1. Flowchart of Giving Lecture Activities

situation is the essence of the transfer process in the activity. In fulfilling the dependability criteria, peer debriefing is one stage to ensure that the entire process is carried out with the correct approach. However, confirmability is not fully passed to ensure that the scope of objective reality is as far as possible. In general, to ensure that the entire process has placed the trustworthiness criteria as a complementary part of the reliability of this research result.

RESULTS AND DISCUSSION

Results

To obtain the expected research results, first, before the entire lecture process begins is to design learning activities that will be followed by course participants. The following activities are designed to support research, namely.

Table 1 Learning Activities

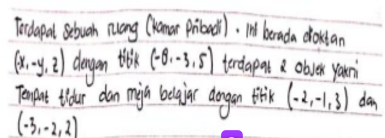
Activity Name	Goal	Output
Explore Three-Dimensional Space	Students can explore the characteristics of three-dimensional space	The ability to represent three-dimensional space and its characteristics.
Determining the Distance of Points in Three-Dimensional Space	Students can determine and predict distances in three-dimensional space	The ability of representation in determining and predicting distances in three-dimensional space
Coordinates of Points in Cartesian, Tube, and Spherical Space	Students can use both Cartesian, cylinder, and spherical coordinates to place points	Representational ability to use Cartesian, cylindrical, and spherical coordinates to place points.
Vectors in Three-Dimensional Space	Students can be able to define and operate vectors in three-dimensional space	Representational ability to define and operate vectors in three-dimensional space

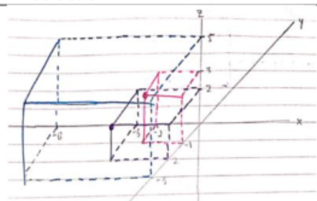
By carrying out these activities in lecture activities which were carried out for 8 meetings, the results of the research were shown in the following figure.

Activity 1: Explore Three-Dimensional Space

In this activity, students are asked to identify objects around them. After that, they use the object as a representation of three-dimensional space. Like what they illustrate this will be interesting as the development of ideas or the idea of bringing objects into the surrounding environment.

Table 2. Construction of Student Answers on the Topic of Exploring Three-Dimensional Space

No	Student Answer Construction	Description
1	You are asked to look for objects in everyday life which are then used as illustrations of three-dimensional space. Show the three-dimensional space on the object!	Problems given to students
2	 Terdapat sebuah ruang (kamar pribadi). Ini berada di oktan (x, -y, z) dengan titik (-8, -3, 5) terdapat 2 objek yakni Tempat tidur dan meja belajar dengan titik (-2, -1, 3) dan (-3, -2, 2)	
	There is a room (private room). It is in octane (-x, -y, z) with dots (-8, -3, 5) there are 2 objects namely the bed and study table with dots (-2, -1, 3) and (-3, - 2, 2)	The process of solving a given problem by selecting the context of a private room. In the room, 3 objects are illustrated, namely a bed and a study table. These two objects are represented by 2 dots, namely (-2, -1, 3) and (-3, -2, 2).

No	Student Answer Construction	Description
3	 The dot image in the three-dimensional Cartesian space above is shown to place objects in the private room.	

In Table 2, the problem given is looking for objects that exist in everyday life. The object relates to the use of three-dimensional space. In a student's work, a private room is used as an illustrated situation for a three-dimensional space. This room is a representation of the concept of a three-dimensional space built by the student. Although the object introduced in this case is only in the form of a point. At least the placement of these objects initiates the use of the concept of space in the study of analytic geometry. Of course, the ability that is built with this activity is exploratory. Not infrequently this ability is used especially in situations of recognizing space. With good space recognition, the benefit that can be obtained is the placement of the right object at the right point so that in turn it will have an impact on optimizing the space based on its designation.

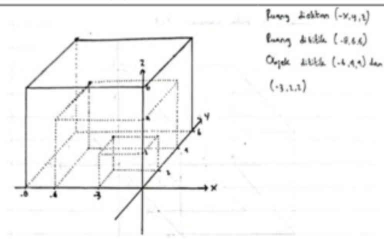
From this description, what is shown by the students from the work they do follows the following stages, 1) Identification of objects related to daily life, in this case, the chosen one is a private room. 2) Connect the situation of the private room with the illustration of the three-dimensional space. 3) Using the concept of three-dimensional space and objects in the private room, in this case, the object is represented by a point. 4) Use pictures to visualize what was done in steps 1, 2, and 3.

Activity 2: Determining the Distance of Points in Three-Dimensional Space

Distance is an important part of the use of space. To be able to determine the distance between two or more objects requires the ability to recognize the distance of the object. Mathematically, the distance between two objects can be calculated by the distance norm (|d|, d = distance). For three-dimensional space, the position of the object is different when compared to when in two-dimensional space. Even so, the position of objects in space is determined by the 3 dimensions that place the object in its place. For students in Space Analytical Geometry learning, distance learning is not only training to determine the distance norm, but they need to take advantage of space to place objects and calculate the distance between these objects. object loci in space.

Table 3. Construction of Student Answers Topic Determining Distances to Points in Three-Dimensional Space

No	Student Answer Construction	Description
1	Hitunglah·jarak·kedua·titik·pada·gambar·tugas·sebelumnya¶ Calculate the distance between the two points in the previous task drawing!	Problems given to students
2	Diketahui·:·A=(-6,4,4)·dan·B=(-3,2,2)¶ The completion plan that is prepared begins by identifying the information obtained from the given problem.	
3	d(AB)·=·$\sqrt{\lvert(-3)-(-6)\rvert^2+\lvert 2-4\rvert^2+\lvert 2-4\rvert^2}$ =$\sqrt{3^2+2^2+2^2}$¶ =$\sqrt{9+4+4}$¶ =$\sqrt{17}$¶ The problem-solving process is applied using the known distance formula. From the work shown, the application of the formula used shows that there are no problems, running well and smoothly.	

No	Student Answer Construction	Description
4	 Draw points in three-dimensional Cartesian space	

In Table 3, the challenge given to students is to determine the distance by using the placement of objects in the previous assignment. Based on these questions, as seen from what the students did, before determining the distance between objects in space, the placement of objects in space, for example, Cartesian coordinates was done as a form of object orientation. In this orientation activity, it is not easy to orient this object where three dimensions of space must be considered to ensure that the placement of the object is in the right place. As described in Table 3 above, the usual method follows the following procedure, 1) Plot the points on the x, y, and z axes, 2) Determine the position where the x and y points meet in the XY plane, 3) Lift the point (x, y) corresponds to the position of the point on the z-axis. This way is also done at other points, for example in the task they are points A(-6, 4, 4) and B(-3, 2, 2).

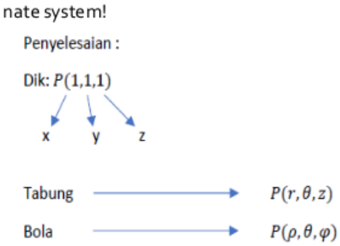
After the position of the two points is placed in space, the distance determination (d(AB)) is carried out using the distance formula in space and as shown in the figure, the distance AB is the $\sqrt{17}$.

From this procedure, some of the representations used stem from the placement of points on the axes of the coordinate system. The representation in the same way is also applied to other points. Because determining the distance requires more than one point it takes a minimum of 2 points. To make it look clearer, the representation of these points is visible using pictures. So, the form of object representation is done in addition to the placement of points or objects, it is also equipped with forming images using dotted lines to ensure the accuracy of objects in space.

Activity 3: Coordinates of Points on Cartesian, Cylindrical Spaces, and Spheres

For the activity in this section, students are given problems in the form of questions that expect them to convert points in the coordinate system. The conversion is directed from three-dimensional Cartesian coordinates to cylindrical and spherical space coordinates.

Table 4. Student Answer Construction Topic Coordinates of Points on Cartesian, Cylindrical, and Spherical

No	Student Answer Construction	Description
1	Diketahui titik P(1,1,1) pada sistem koordinat ubahlah posisi titik tersebut untuk sistem koordinat tabung & bola!	
	Given the point P(1, 1, 1) in the coordinate system, change the position of the point for the cylindrical and spherical coordinate system!	Problems given to students
2		
	Completion plans are arranged in a good systematic manner. It begins by presenting the known information and the representation of the question in the problem is made in the form of an arrow diagram that connects the type of space and the arrangement of its coordinate points	

No	Student Answer Construction	Description
3	Mencari komponen yang diperlukan untuk menentukan koordinat dari tabung dan bola • $r = \sqrt{x^2 + y^2}$ $= \sqrt{1^2 + 1^2}$ $= \sqrt{2}$ $Tan\,\theta = \frac{x}{y}$, $Tan\,\theta = 1$, $\theta = 45° = \frac{\pi}{4}$ • $\rho = \sqrt{x^2 + y^2 + z^2}$ $= \sqrt{1^2 + 1^2 + 1^2}$ $= \sqrt{3}$ • $r = \rho \sin\varphi$, $\sin\varphi = \frac{r}{\rho}$, $\sin\varphi = \frac{\sqrt{2}}{\sqrt{3}}$, $\varphi = \arcsin\frac{\sqrt{2}}{\sqrt{3}}$, $\varphi = 54{,}74°$ • $z = \rho \cos\varphi$, $\cos\varphi = \frac{r}{\rho}$, $\cos\varphi = \frac{1}{\sqrt{3}}$, $\varphi = \arccos\frac{1}{\sqrt{3}}$, $\varphi = 54{,}74°$	The problem-solving process shown in the figure to the right is to parse any components and determine their values. The description of the values obtained is then used to answer the core questions of this problem.
4	Tabung → $P(r, \theta, z)$ → $P(\sqrt{2}, \frac{\pi}{4}, 1)$ Bola → $P(\rho, \theta, \varphi)$ → $P(\sqrt{3}, \frac{\pi}{4}, 54{,}74°)$	The conclusions obtained from the problem-solving process are based on the questions attached to the problem and adjusted using the results of the problem-solving process shown previously

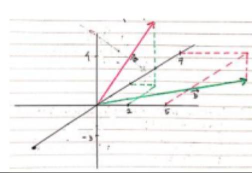
An understanding of how to convert point coordinates from Cartesian to cylindrical and spherical coordinates requires knowledge related to it. The knowledge in question is what the coordinates for the cylindrical space and spherical space look like. For the cylindrical space coordinates, it is filled by (r, θ, z) and the spherical coordinates are filled by (ρ, θ, ϕ). R = ρ, therefore θ in cylindrical space is also used for spherical space, but spherical space is formed not only by the angle from the xy-axis region but also by the z-axis. Then for the cylinder space, the height of the cylinder is none other than the z-axis so the third point in the coordinates of the tube space is the z-axis. Meanwhile, for a spherical space where the symbol used is ϕ, the angle formed between the z-axis and ρ.

Based on this review, the working steps taken by students were as follows: 1) Identifying the coordinates of each space, and converting Cartesian to cylinders and spheres. 2) Determine some required values, for example for tubes r and θ, while for balls, namely ρ dan ϕ. After all that is needed is complete, then these values are used to complete the coordinate components of each space.

Activity 4: Vectors in Three-Dimensional Space

For the activity in this section, students are given problems in the form of questions that expect them to create vectors placed in a three-dimensional space coordinate system. The results are shown in the table below.

Table 5. Construction of Student Answers on the Topic of Vectors in Three-Dimensional Space

No	Student Answer Construction	Description
1	. Silahkan buat vektor pada ruang tiga dimensi ! Please vector in three-dimensional space!	Problems given to students
2	• Dalam bentuk vektor baris $\vec{a} = 2\vec{i} + 3\vec{j} + 4\vec{k} = (2, 3, 4)$ $\vec{b} = 5\vec{i} + 7\vec{j} - 3\vec{k} = (5, 7, -3)$ • Dalam bentuk vektor kolom $\vec{a} = 2\vec{i} - 3\vec{j} + 4\vec{k} = \begin{pmatrix} 2 \\ 3 \\ 4 \end{pmatrix}$ $\vec{b} = 5\vec{i} + 7\vec{j} - 3\vec{k} = \begin{pmatrix} 5 \\ 7 \\ -3 \end{pmatrix}$ The problem-solving process shown in this issue is very well developed. The presentation of the given vectors begins by giving a general shape before being converted into row vectors and column vectors. In other words, student work has progressed with some review in this case of column and row vectors.	
3		

No	Student Answer Construction	Description
		Draw points in three-dimensional Cartesian space. As seen from this picture, there are 2 octane chambers used, namely octane 1 (xyz) and 5 (xy-z). The use of 2 different colors, namely red and green indicates the presence of these vectors. This is a good attempt at demonstrating the quality of performance.

Although the questions given explore the knowledge and understanding possessed by students by asking the question "Please create a vector in a three-dimensional space!", this question requires creative responses from students where they are expected to create a three-dimensional space whose contents are vectors. To answer this question, knowledge is needed in addition to three-dimensional space, as well as vectors that have values and directions. In addition to writing examples of vector numbers, students are also expected to be able to visualize what the shape of the vector depicted in the three-dimensional space looks like.

As shown in Table 5, students' declarative knowledge is shown through how the answers are given, namely row vectors and column vectors. In other words, the description of the answer shows what the student knows. Then the response to the questions given is continued by making a visualization of the vector in the three-dimensional space. For this reason, number 3 in Table 5 shows a three-dimensional space image with vectors given in red and green colors.

Discussion

From the research findings stated above, the representation shown by students in their work is described in the following description:

The methods and materials of student representation depend on the knowledge they have, the wider the knowledge they have of the various presentation information provided. What is meant in identifying objects where the selected object is related to daily life, in this case, the chosen one is a private room. Then to connect the situation of the private room with the illustration of a three-dimensional space, it involves the concept of representation, such as the representation of objects in the private room in the form of dots. With this object, representation supports the visualization of images in three-dimensional space. To develop representation skills, it does require understanding mathematical concepts and attaching their relation to other mathematical concepts (Allen et al., 2020). Through the relationships between these concepts, representations can be used to recognize the relationships between concepts and apply them to realistic problems through modeling (Meilon et al., 2019). In its implementation, it emphasizes that the knowledge and learning experiences possessed and developed by students can lead them to demonstrate their representational abilities to be richer and support ways of solving problems, or experiences to develop knowledge, use media, and practice problem-solving (Astuti, 2017). (Kozma, 2003) suggests that this representational ability provides learners with an authentic learning environment in which they use these abilities to explain phenomena. The ability to represent an object is also a form of confidence in interpreting and communicating mathematical concepts through abstraction in the form of symbols that can be understood logically (Nurlisna et al., 2020). Indirectly, the learning process that is built with representational abilities forms a learning environment that enriches the learner's experience.

Then, object representation is usually supported by the form of treatment in the form of placing points or objects that are equipped with forming images using dotted lines to ensure the accuracy of objects in space. Whatever is done is part of the form of representation where they think about the problem and useful tools to solve the problem (Sabirin, 2014). In line with the explanation (De Cock, 2012) that the ability of representation or the ability of multiple representations can be a useful tool to facilitate problem-solving. Although it is not stated that the goal is an abstraction, the formation of valuable learning experiences may be in line with the argument (Kaput, 1989) that the learning outcomes can be used for further learning activities where it is possible to see complex ideas in new ways and apply them more effectively. Mathematical understanding and mathematical representation are an integral part of problem-solving (Minarni et al., 2016). That way, improvements to mathematical representation skills will lead students to improve their problem-solving abilities.

Representation activities become complex when converting point coordinates from Cartesian to tube and spherical coordinates in addition to requiring knowledge related to this, students will also explore the components needed to obtain converted points. (Kaput, 1989) found that the use of multiple representations helped students to give a better picture of mathematical concepts and provided various concretizations of concepts. This description relies on differences in the performance shown by students, (Kohl & Finkelstein, 2005) suggesting that differences in performance depend on several things, including student expectations, prior knowledge, metacognitive skills, and specific contextual features of the problem and representation.

The development of previous knowledge can be done by asking questions that require creative responses from students or users, if this is done, student performance will develop according to the challenges given. Working on the problem of representation ability will direct the user to propose strategic considerations based on the characteristics of the problem at hand (Munn et al., n.d.). Although it is different from (Hegarty & Kozhevnikov, 1999) where the use of pictorial representations is negatively related to success in solving mathematical problems, in student performance this is getting clearer and better developed using pictures. Connecting the good opinion that has been put forward where representation is a kind of configuration process to present something in different situations which involves identification, selection, and conveying of ideas (Goldin, 2015; Fennema et al., 1999; (Seeger et al., 1998). Other implementations were Nurlisna et al. (2020) by utilizing software and developing its function as a medium to present other learning tools in the form of a worksheet. The goal is that mathematical representation skills developed in learning activities are not only the instructions needed to be clear but also to facilitate the development of the use of these skills so that they support the achievement of the expected learning objectives. The implication of the research is this kind of learning opportunity must be prepared by teachers to students, to prospective teacher students so that they not only hone their mathematical understanding and representation (Minarni et al., 2016), especially students as prospective teachers who are enrichment with knowledge leads to creative skills. Also, enhancing skills that utilize such knowledge enriches the learning experience (Cambaya & Tan, 2022). However, there are several constraints and limitations in the research regarding the development of students' knowledge, where representation activities would further flourish if supported by visualization activities. Hence, this study would be interesting to explore visualization activities. Naturally, other skills would develop as part of the representation ability.

Implication

The importance of nurturing representation skills in mathematics education cannot be overstated. These skills involve comprehending mathematical concepts and establishing connections with other mathematical ideas. By refining representation skills, students can recognize the relationships between concepts and apply them to solve real-world problems through modeling. The implementation of learning underscores that students' knowledge and learning experiences can lead them to demonstrate more robust representational abilities, supporting effective problem-solving and knowledge development using media and practical application in problem-solving. Representation skills also foster an authentic learning environment where students can elucidate phenomena and build confidence in conveying mathematical concepts through logically comprehensible symbols.

The complexity of representation activities in the mathematical context, especially in point coordinate conversion and the use of multiple representations, aids in developing prior knowledge and leveraging visuals to enhance the understanding of mathematical concepts. Despite constraints and limitations in students' knowledge development, there is potential for further enhancement through visualization activities. Overall, this writing emphasizes the urgency and positive impact of developing representation skills in improving students' understanding and mathematical proficiency.

Limitation

However, the limitations of this study lie in the lack of detailed exploration regarding which specific aspects of students' representation skills have reached an optimal level. Therefore, the foundation for improvement and skill enhancement can be identified through the development of problems or learning activities. Additionally, the insights gained from this research are expected to reveal the extent of students' representation skills, shedding light on areas that may require improvement, particularly concerning the complexity or visualization aspects of representation skills.

CONCLUSION

Based on the discussion stated above, the research results obtained lead to conclusions that can be drawn as follows: 1) Involving problems in everyday life is one way to explore students' representational abilities, 2) Complex and non-routine problems will trigger students to develop representational skills where they will explore various related information to solve the problem. 3) The challenges given to students should trigger creative responses from students so that they not only form knowledge but also have a good learning experience. 4) Visualization techniques in the form of pictures, diagrams, or other similar are the right opportunity for students to develop representational abilities.

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