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Prospective Mathematics Teacher Students' Experiences in Visual Programming: Difficulties and Obstacles in Designing Digital Media for Numeracy Learning

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Abstract: Prospective mathematics teacher students' lack of understanding of basic math concepts, such as numeracy, is one of the main challenges in learning. In the era of rapid technological development, they must adapt, one of which is through visual programming to strengthen their numeracy. However, they often face difficulties and obstacles in the learning process of visual programming, both from technical and non-technical aspects. This research aims to analyze the difficulties and obstacles of prospective mathematics teacher students in learning visual programming. The research used the Colaizzi method to analyze qualitative data, which was then combined with clustering techniques to group the problems into five main clusters. The results show that the main difficulties are programming related knowledge (syntax/rules for writing code, determining variables, concepts and principles, functions and parameters, define code structure and loops, apply in numeracy/mathematics concept), skills in programming, understanding of program semantics (code), debugging, lack of practice. In addition, the obstacles faced by prospective mathematics teacher students are a lack of skills and understanding of basic programming concepts, such as code structure, syntax, and debugging, as well as the application of concepts to the context of numeracy/mathematics. In addition, there are internal barriers in the form of negative perceptions, dislike for programming, and low motivation to learn. This problem is exacerbated by the heavy course load, such as learning many topics quickly and teaching methods that are less structured and do not support effective learning. These difficulties and obstacles need to be addressed through more targeted and innovative learning approaches, such as integrating technology that supports a basic understanding of programming and training that builds motivation and changes negative perceptions towards visual programming.

Keywords: visual programming, difficulties, obstacles, digital media, numeracy.

▪ INTRODUCTION

Mathematics is important topic in the education curriculum in Indonesia. Mathematics is almost always in the learning curriculum at every level of education. Mathematics is a science formed from the results of human thought related to ideas, processes, and reasoning (He & Shen, 2022). Although it has been taught at every level of education, there is always the same problem, namely, the potential ability of prospective mathematics teacher students to learn mathematics is still very limited. This is a challenge, considering that mathematics has an important role as an essential competence that everyone must have (Sondore et al., 2016). Based on data from the National Examination Results Report by the Education Assessment Center of the Ministry of Education and Culture, the average score of the National Mathematics Examination for high school science majors in Indonesia in 2019 was only around 39.33 (on a scale of 100), this figure is the lowest when compared to other subjects tested. (Kemdikbud, 2019). One of the factors contributing to this problem is prospective mathematics teacher students' lack of understanding of basic math concepts such as numeracy. Numeracy is the ability to understand and use mathematical concepts in various contexts, such as understanding, interpreting, and using numbers and

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mathematical concepts to solve problems in everyday life (Gula & Lovric, 2024). Numeracy learning is key to addressing this issue. Numeracy includes the ability to count numbers and the skills to apply mathematical knowledge in everyday life. Therefore, prospective mathematics teacher students need to improve their numeracy skills so that they not only understand mathematical concepts but can also use them practically to solve their problems.

The rapid advancement of technology demands that prospective mathematics teacher students quickly adapt and innovate to create effective learning media that enhance their understanding, particularly in numeracy. Learning media are crucial tools for facilitating the teaching and learning process, making the conveyed messages clearer and ensuring that educational goals are achieved effectively and efficiently (Zhang, 2022). According to Permatasari et al. (2024), the use of learning media also has a significant psychological impact on students, such as increasing their interest, motivation, and enthusiasm for learning. In this context, visual programming becomes a critical element in developing interactive learning media, as it enables the representation of abstract mathematical concepts in a more concrete manner. Research shows that visual programming, such as Scratch or programming robots, can strengthen algorithmic and computational thinking skills, which are fundamental in solving mathematical problems (Kaufmann & Stenseth, 2021; Shumway et al, 2023). This approach also provides dynamic learning experiences, encourages creative exploration, and delivers immediate feedback, which in turn enhances students' motivation (Laurent et al, 2022).

However, prospective mathematics teacher students often face various challenges, including a lack of programming experience, limited access to supporting facilities, and insufficient time to learn these technical skills amidst a demanding academic schedule. Nevertheless, the potential of visual programming as a pedagogical tool capable of bridging mathematical logic with technological interactivity makes it highly relevant in modern mathematics education.

Therefore, this research aims to describe the various causes of problems faced by prospective mathematics teacher students, particularly in creating learning media based on visual programming. This analysis is expected to provide a comprehensive understanding of the factors that serve as obstacles, whether technical, academic, or psychological. Consequently, the findings can serve as a foundation for formulating effective and practical solutions, addressing prospective mathematics teacher students' challenges appropriately. This step is also expected to support the development of prospective mathematics teacher students' competencies while improving the quality of mathematics education in schools.

Therefore, this research conducted to analyze the difficulties and obstacles of prospective mathematics teacher students in learning visual programming, especially in designing digital media for numeracy learning. This analysis is expected to provide a more comprehensive understanding of the factors that become difficulties and obstacles in terms of technical, academic, and psychological. Thus, the results of this analysis can be the basis for formulating practical and applicable solutions so that the problems faced by prospective mathematics teacher students can be overcome appropriately. This step is also expected to support the development of prospective mathematics teacher students competencies and improve the quality of mathematics learning in schools.

▪ METHOD

Participants

The research subjects in this research were prospective mathematics teacher students of Mathematics Education at a university in Surabaya, Indonesia, and enrolled in the odd semester of the 2024 - 2025 academic year. Subjects were selected based on two main criteria, namely high expression skills and willingness to participate voluntarily. The research data was collected through the distribution of a questionnaire designed to explore prospective mathematics teacher students' experiences with visual programming and the obstacles they faced during the process. The questionnaire aimed to get a comprehensive picture of the level of skills, understanding, and obstacles experienced by prospective mathematics teacher students in visual programming.

A total of 115 students participated in the questionnaire, which grouped them based on programming experience and project success rates. In the group with less than 4 meetings, most students had low success rates, while the group with 5 to 8 meetings, consisting of 17 respondents, showed a more even distribution, with the majority achieving moderate success rates. The group with more than 8 meetings, consisting of 65 respondents, recorded the highest success rates, with most participants achieving high levels of success. The diversity of experience among the study subjects provides a comprehensive overview of the challenges faced by students in visual programming, from beginners to more advanced learners. This also allows for a deeper analysis of the factors influencing students' success, including differences in skills, understanding of the material, and the effectiveness of the guidance they received during the learning process.

Research Design and Procedures

This research is a phenomenological approach. Phenomenological research is qualitative research that aims to understand the subjective experience of individuals towards a particular phenomenon (Matua & Van Der Wal, 2015). This phenomenological research uses analysis based on the Colaizzi method to deeply understand the experiences of prospective mathematics teacher students in learning visual programming. The Colaizzi method was chosen because it has advantages in analyzing qualitative data by revealing emerging themes and interrelated relationships between themes so as to explore the deep meaning of participants' experiences in phenomenological research (Wirihana et al., 2018). Its systematic process ensures the accuracy, validity, and interpretation of findings through the revalidation of participants, resulting in more prosperous and credible data.

This method allowed the researcher to explore the perceptions, obstacles, and barriers experienced by prospective mathematics teacher students during the learning process. The analysis was conducted following systematic stages that included data familiarization, identification of significant statements, formulation of meaning, clustering of themes, preparation of a comprehensive description, simplification into a fundamental structure, and validation of results to participants. This approach is expected to provide a comprehensive picture of the causes of prospective mathematics teacher students' failures and difficulties in learning visual programming so that it can be used as a basis for improving the effectiveness of learning in this field.

In data collection, the instruments used in this research was questionnaire. The researchers developed the questionnaire in this research and validated it by a mathematics education expert to ensure its validity and relevance for assessing prospective mathematics teacher students' difficulties and obstacles in learning visual programming.

Instrument

The questionnaire was distributed online through the Google Forms platform to facilitate participation and reach prospective mathematics teacher students outside the campus. Each participant was given one week to complete the questionnaire. Instructions for completing the questionnaire were provided in the form of brief instructions explaining the purpose of the research and how to answer the questions honestly and openly.

The instrument used in this research was an open-ended and closed-ended questionnaire developed by the researcher to explore prospective mathematics teacher students' experiences in learning visual programming. This questionnaire consists of two main parts: (1) Demographic questions include data such as name, semester, class, and previous experience in visual programming either during college or junior high school. The assessment in terms of experience is divided into two categories, namely, the number of meetings conducted and the level of success in working on visual programming projects. (2) The main questions were designed to identify obstacles, perceptions, and barriers faced by prospective mathematics teacher students in the learning process of visual programming. The obstacles include difficulties in syntax (code writing rules), programming concepts and principles, and applying numeracy/mathematics concepts. In terms of causes, the questions asked are divided into three categories: causes derived from programming problems, internal problems, and problems in prospective mathematics teacher student learning activities.

Data Analysis

Based on (Lune & Berg, 2017), the collected data was analyzed using the Colaizzi method, which involves several systematic steps. First, data introduction, researchers read through the collected data to gain a general understanding of the prospective mathematics teacher students experience. Second, identification of significant statements, researchers mark statements considered important and relevant to the research objectives. Third, formulation of meaning, researchers interpret the marked statements to reveal the meaning they contain). Fourth, theme grouping, researchers group the meanings found into interrelated themes. Fifth, comprehensive description, researchers develop a comprehensive description of the prospective mathematics teacher student experience based on the themes that have been discovered. Sixth, simplification into a fundamental structure, researchers organize the findings into simpler, easier-to-understand structures), Seventh, validation of results, researchers validate the analysis results by asking participants to review the findings).

In the sixth stage, or simplifying the data into a more straightforward structure, researchers used a clustering method to group respondents based on similar patterns in their experiences related to difficulties and obstacles in visual programming. The clustering process is carried out using the K-Means Clustering approach, which is one of the effective unsupervised learning techniques to divide data into several groups or clusters based on certain similarities (Xie et al., 2020). This technique was chosen for its ability to simplify complex data structures by clustering data based on the Euclidean distance between data points and the cluster centre (centroid). Based on (Han et al., 2011), the K-Means Clustering algorithm starts by determining the number of clusters (k) and randomly selecting the initial cluster centres. Then, the data is grouped into clusters based on the closest distance to the cluster centre. Next, the cluster centres are updated by calculating the average data position for each cluster. This process is repeated until the cluster centres do not change or reach convergence. The final result is evaluated to ensure optimal clustering. This clustering process will provide a clear picture of the difficulties and obstacles experienced by prospective mathematics teacher students in visual programming by grouping data based on certain similarities.

▪ RESULT AND DISSCUSSION

Identification of Key Themes

Based on the assessment process in the early stages of the Colaizzi method, several prominent themes were found, namely: Theme 1: Difficulties experienced by prospective mathematics teacher students in the visual programming process. Theme 2Causes of failure of prospective mathematics teacher students in projects visual programming.

The main obstacles experienced by prospective mathematics teacher students in visual programming in Theme 1 were grouped into five subthemes, namely: "Knowledge related to programming", "Skills in programming", "Understanding program semantics (code)", "Debugging", and "Lack of practice". An explanation of Theme 1 and the identified subthemes can be seen in Table 1.

Table 1. Classification of difficulties faced by prospective mathematics teacher students

No	Difficulties Faced	Description
1	Programming related knowledge	Obstacles that arise due to lack of knowledge related to basic programming
	a. None	Have no constraints related to programming knowledge
	b. Syntax (rules for writing code)	Difficulty in knowing and remembering syntax when writing programs
	c. Determining variables	It is difficult to determine the variables to be used in the program and assign them
	d. Concepts and principles	Understanding certain concepts, principles, or facts related to programming languages is tricky
	e. Functions and parameters	Difficulty in remembering functions and parameters used in programming
	f. Define code structure and loops	Difficulty in determining which decision structure and loop to use
	g. Apply in numeracy/mathematics concept	Difficulty in applying mathematical logic to the program
2	Skills in programming	Difficulty in determining the strategy when reviewing his programming knowledge and designing solutions to problems.
3	Understanding of program semantics (code)	Difficulty in understanding semantics when writing program code
4	Debugging	Difficulty in correcting errors in previously written program code
5	Lack of practice	Obstacles that arise due to lack of experience

However, to make it easier to understand the data's content, the questionnaire's results will be presented in the form of a frequency table. This presentation aims to provide a more structured picture of the pattern of respondents' responses so that each category or theme that emerges can be seen clearly and quantitatively. With the frequency table, readers can easily identify the number of respondents who expressed an opinion or experienced certain obstacles. In addition, this presentation helps identify the data distribution, allowing further analysis to find relationships or trends relevant to the research objectives. The questionnaire results are based on the difficulties experienced by prospective mathematics teacher students in the visual programming process (Theme 1), which can be seen in Table 2.

Table 2. Results of theme 1 identification

No	Difficulties Faced	Frequency
1	Programming related knowledge	25
	a. None	2
	b. Syntax (rules for writing code)	25
	c. Determining variables	5
	d. Concepts and principles	14
	e. Functions and parameters	9
	f. Define code structure and loops	40
	g. Apply in numeracy/mathematics concept	20
2	Skills in programming	18
3	Understanding of program semantics (code)	35
4	Debugging	27
5	Lack of practice	10

Table 2 shows that the most dominant obstacle experienced by prospective mathematics teacher students is difficulty in understanding program semantics. Regarding "Programming Knowledge," most prospective mathematics teacher students faced difficulties in determining code structure and using loops. The following are some statements from research subjects (R) regarding problems in visual programming:

R1: "When creating a program I am sometimes confused about how to write the syntax or code without an example first, I also don't understand the logic in using the code, when an error occurs I sometimes don't know at what step I made a mistake."
R2: "My main obstacle is my lack of in-depth understanding of the basic concepts of programming, including the difficulty of defining the right variables, understanding the logic of program flow, as well as facing the great challenge of memorizing and mastering the programming language syntax well."
R3: "Sometimes I feel confused in understanding the function of the code I use, especially in the context of how the code works as a whole to build the desired program and how each part is connected."
R4: "Lack of knowledge and skills related to programming, besides that this is my first time learning programming so I am still in the learning process. Also, I still have difficulty determining the code structure and loops."

R5: "I have difficulty in understanding the error logic when debugging, especially when the error message is not clear, making it difficult to find solutions to improve the code in visual programming."

R6: "Actually, there are no significant obstacles. It's just that the problem is that we don't have programming subjects in high school. So we are still unfamiliar with programming material. And it takes a lot of time to learn. Unlike those who have received programming-related material from high school because they have adopted the independent curriculum, so they may be more capable in programming."

As for the causes of failure of prospective mathematics teacher students in the project (Theme 2) are grouped into three subthemes, namely: "Caused by problems in the programming process", "Caused by problems within prospective mathematics teacher students (internal)", and "Caused by problems in lecture activities". An explanation of the identified subthemes can be seen in Table 3.

Table 3. Classification of causes of visual programming project failure

Causes of Failure	Description
Problems in the programming process	
Following the code editor's comments on errors	Due to the lack of understanding of how to follow the code editor's comments, errors in the program are challenging to fix efficiently.
Does not loop	Due to the lack of implementation of loops, the program's automation and code efficiency processes are hampered.
Lack of knowledge	Due to the lack of knowledge, understanding basic concepts and application of programming techniques is limited in program development.
Did not write the algorithm	Due to not writing algorithms, the program's logical structure becomes undirected, making the development process less efficient.
Utilize code that is already available.	Due to the lack of utilization of readily available code, time efficiency and optimization of program development are hampered.
errors in choosing variables in numeracy/mathematics	Caused by incorrectly selecting variables in numeration/mathematics, calculations and program logic become inaccurate, leading to incorrect results.
Problems from prospective mathematics teacher students (Internal)	
Anxiety (feeling anxious)	Caused by anxiety, focus and concentration in completing programming tasks are disrupted, hindering the process of understanding and problem-solving.
Disliked the program created	Due to the dislike of the program created, motivation and involvement in program

Causes of Failure	Description
	development decreases, affecting the quality of the final output.
Perception/prejudice towards programming	Due to negative perceptions or prejudices towards programming, interest and motivation to learn and develop programming skills are limited.
Lack of attention to the program at hand	Due to a lack of attention to the program at hand, errors and flaws in program logic or syntax are often missed, hampering the quality of the final output.
Problems with lecture/learning activities	
Time allocation for implementation or creating a program/project is insufficient	Due to insufficient time allocation for program/project implementation or creation, the quality of the result is hampered, and development cannot be optimized.
Learn many topics in a short time.	Due to learning many topics quickly, in-depth understanding of each topic is limited, hindering the practical application of concepts.
Teaching visual programmer topics without following a step-by-step method or too fast	Due to teaching visual programming topics without following a step-by-step method or too quickly, teacher students have difficulty understanding concepts in depth, resulting in less effective learning and limited application of skills.
The explanation of problems or topics related to numeracy/mathematics with programming is unclear.	Due to unclear explanations of problems or topics related to numeracy/mathematics and programming, prospective mathematics teacher students' understanding of the relationship between mathematical concepts and their application in programming is limited, hindering effective learning.

To make it easier to understand the data's content, the questionnaire's results will be presented in the form of a frequency table, which can be seen in Table 4.

Table 4. Results of theme 2 Identification

No	Causes of Failure	Frequency
	Problems in the programming process	
1	Following the code editor's comments on errors	0
2	Does not loop	5
3	Lack of knowledge	79
4	Did not write the algorithm	0
5	Utilize code that is already available	6
6	Errors in choosing variables in numeracy/mathematics	25
	Problems from prospective mathematics teacher students (Internal)	
1	Anxiety (feeling anxious)	31
2	Disliked the program created	7
3	Perception/prejudice towards programming	28
4	Lack of attention to the program at hand	49

No	Causes of Failure	Frequency
	Problems with lecture/learning activities	
1	Time allocation for implementation or creating a program/project is insufficient	24
2	Learn many topics in a short time	53
3	Teaching visual programming topics without following the step-by-step or too fast	31
4	explanation of the problem or topic numeracy/mathematics with less clear programming	7

Table 4 shows that their lack of knowledge dominates the leading cause of prospective mathematics teacher students' failure in programming. Meanwhile, failures related to internal problems were mainly caused by prospective mathematics teacher students' lack of attention to the program, resulting in many errors. Failures caused by lecture activities most often occur because prospective mathematics teacher students have difficulty learning many topics quickly. The following statements from research subjects (R) clearly illustrate this issue:

R7: "I feel anxious when doing programming assignments, which causes my focus and concentration to be disrupted. This hinders my understanding of the material and makes it difficult for me to solve problems that arise."

R8: "I often do not make use of readily available code, even though this could have improved time efficiency and optimized program development. As a result, I had to rewrite code that could have been reused, hampering the development process."

R9: "The anxiety I feel disrupts my focus and concentration when doing programming assignments. This hindered my understanding of the materialand slowed down the problem-solving process, making it difficult for me to complete the assignment properly."

R10: "My lack of attentionand thoroughness to the program at hand often leads to errors in logic or syntax being missed. This hampers the quality of the final output, as small problems that are not corrected can affect the overall performance of the program."

R11: "The limited time allocation for program/project implementation or creation makes it difficult for me to complete the task properly. As a result, the quality of the final result is hampered, andprogram development cannot be carried out optimally as expected."

R12: "Visual programming lessons delivered without a step-by-step method or too quickly made it difficult for me to understand the concepts well. This reduces the effectiveness of my learning process, making it difficult for me to apply the skills learned."

Structure Simplification Using Clustering Method

The clustering method in this study aims to identify patterns emerging from the data on challenges and causes of failure experienced by prospective mathematics teacher students in learning visual programming. Clustering analysis is used to group the data based on similar characteristics, allowing the most dominant difficulties to be revealed and the relationships between various causal factors to be understood. Consequently, this method not only maps the distribution of problems systematically but also aids researchers in further analyzing specific challenges faced by prospective mathematics teacher students during the process of learning visual programming. This approach provides deeper insights to formulate more effective solutions or learning strategies to address the identified obstacles.

Data processing with the clustering method in this research was carried out using a program created using Python programming. Python was chosen because it has various libraries that support clustering analysis, such as Scikit-learn for the K-means algorithm, as well as other libraries, such as NumPy and Pandas for data processing and Matplotlib or Seaborn for visualization of results. Using Python, the clustering process can be done efficiently, from data preprocessing and application of clustering algorithms to evaluation and visualization of results, thus supporting accurate and structured analysis.

Data Preprocessing

This stage involves data cleaning, such as handling missing values and removing duplicate data that may affect the clustering results. In addition, if the data has different scales, normalization is performed to equalize the scale between variables. The following are the results of the data readiness check:

Duplicate Rows Count : 18

	Kendala Utama	Kendala Khusus Pemrograman	Terkait Proses Pemrograman	Terkait Masalah Internal	Terkait Kegiatan
0	1	6	3	4	3
1	5	7	3	4	3
2	1	4	3	4	4
3	1	3	3	4	2
4	3	2	3	4	3
5	1	4	3	4	3
6	2	6	3	4	3
7	1	5	3	4	1
8	3	7	6	3	2
9	3	5	3	4	1

Figure 1. Duplicate data removal process

After ensuring that the dataset has no missing or empty data, it confirms that all information is available for analysis without the risk of distortion due to incomplete values.. Furthermore, in Figure 1, identifying and removing duplicate data is performed to maintain the dataset's quality. Duplicate data can cause bias in the analysis results, so this removal is an important step to improve the accuracy and validity of the research. In the process, 18 duplicates were found and removed, ensuring that the data used was utterly unique and reliable. With a clean and verified dataset, the analysis process could continue.

Data Analysis Results

After the program was entirely run, the following data analysis results were obtained as shown ini Figure 3. After the data cleaning process, which involved removing 18 duplicates, 97 unique data combinations were obtained, which formed the basis for further analysis. The clustering process resulted in grouping the data into five clusters, visualized in Figure 2. Cluster 0, denoted in purple, is the most dominant group, with 33 respondents. Cluster 1, denoted in blue, consists of 19 respondents. Next, Cluster 2, denoted in bluish-green, includes 22 respondents. Cluster 3, denoted by green, consists of 17 respondents, while Cluster 4, denoted by yellow, has the least respondents, at 6 people.

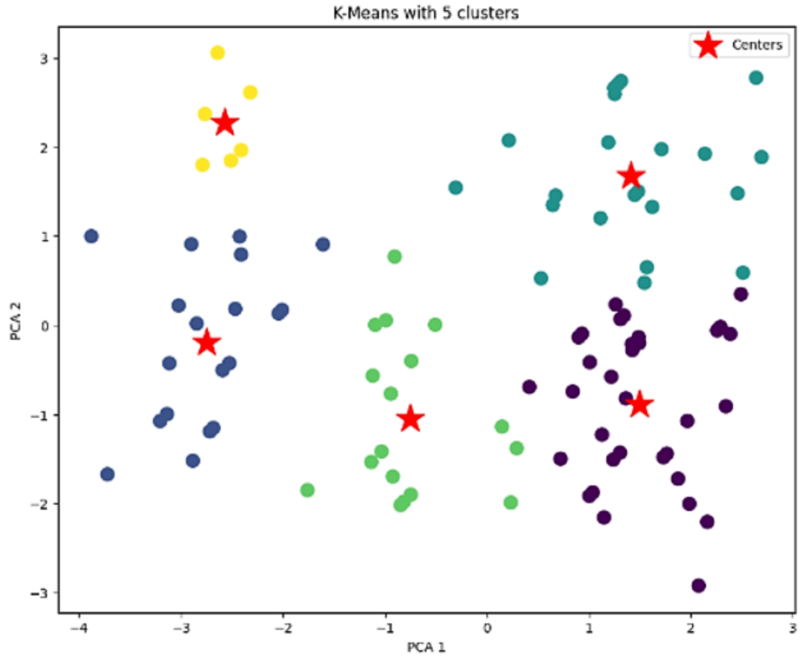

Figure 2. Clustering model

These results show that Cluster 0 is the majority group in the analyzed data, standing out from the other clusters. Determining the number of respondents in each cluster helps provide an overview of the data distribution based on specific characteristics that will be analyzed further. For a deeper understanding of the interpretation of each cluster, a more detailed explanation is presented in Figure 3 and Table 5. The visualizations and tables provide insight into each group's unique patterns and characteristics so that they can be used for decision-making or strategic steps based on the results of this clustering analysis.

```
Rata-rata setiap fitur per cluster dalam DataFrame:
   Cluster  Kendala Utama  Kendala Khusus Pemrograman  \
0        0       1.714286                    6.428571
1        1       2.968750                    2.125000
2        2       3.789474                    6.000000
3        3       3.440000                    6.200000
4        4       1.944444                    4.222222

   Terkait Proses Pemrograman  Terkait Masalah Internal  Terkait Kegiatan
0                    2.904762                  3.095238          2.190476
1                    3.750000                  2.531250          2.343750
2                    5.578947                  2.473684          2.052632
3                    3.480000                  3.120000          2.160000
4                    2.944444                  3.000000          2.055556
```

Figure 3. Clustering result

Based on the analysis results using the clustering method program, the data can be divided into 5 main clusters. To make it easier to understand the results of data analysis. Researchers present the data in a rounded form in Table 4.

Table 4. Clustering results

Cluster	KU	KK	PP	PI	PK
0	2	6	3	3	2
1	3	2	4	3	2
2	4	6	6	2	2
3	3	6	3	3	2
4	2	4	3	3	2

The numbers presented in Table 4 are the indices determined for each subtheme in Table 2 and Table 3. The following is a description of each cluster that appears:

Cluster 0: This group faces significant problems in programming skills and has specific constraints in determining code structures and loops. In addition, they lack programming knowledge and tend to have negative prejudices towards programming. In terms of lectures, they find it difficult due to the large number of topics to learn quickly.

Cluster 1: This group has difficulties understanding the semantics or meaning of the program code and syntax rules. Another major problem is not writing down algorithms before programming. They also have a negative prejudice against programming and feel overwhelmed by the amount of material learned in lectures.

Cluster 2: This group has significant problems in debugging and determining code structure or loops in programming. They also often made mistakes in choosing variables when dealing with numeracy/mathematics. The internal problem faced was a dislike for the programs created, coupled with overcrowded lectures.

Cluster 3: This group had problems understanding the semantics of the program and had difficulty determining the code's or loop's structure. Another programming problem is a lack of knowledge. They are also prejudiced against programming, while the dense course material exacerbates the situation.

Cluster 4: This group has significant constraints on programming skills and difficulty understanding programming concepts and principles. The problem in the programming process is the lack of knowledge, and they also have a negative perception of programming. Overcrowded lectures are also an obstacle.

Moreover, from the use of the clustering method, five main clusters were identified, revealing a combination of challenges and causes of failure in visual programming. This approach allowed for a clearer understanding of the patterns of difficulties faced by prospective mathematics teacher students. Based on the clustering results, it can be concluded that the main obstacles encountered by prospective mathematics teacher students in learning visual programming include a lack of skills and understanding of basic programming concepts, particularly in code structure, syntax, debugging, and application in numeracy or mathematics. Additionally, there are internal issues such as negative perceptions and dislike toward programming, which hinder learning motivation. These challenges are exacerbated by the heavy course load, such as learning many topics in a short time, and the lack of structured teaching methods. Therefore, efforts are needed to strengthen concept understanding, improve programming skills through targeted practice, and design more systematic teaching methods that support the gradual development of prospective mathematics teacher students' abilities.

Validation of Research Results

Validation of the research results was conducted by involving participants in reviewing the findings that had been formulated. Based on the participants' responses, the results of this research were considered accurate and reflected their experiences while learning visual programming. Prospective mathematics teacher students agreed that a lack of understanding of basic concepts, debugging difficulties, and application in numeracy were the main obstacles they faced. In addition, they confirmed that negative perceptions of programming, course load, and unstructured teaching methods hindered the learning process. Feedback from participants also supported the research recommendations, namely the need for systematic learning methods and directed practice to improve prospective mathematics teacher students' skills gradually and effectively.

This research's results align with previous studies that discuss prospective mathematics teacher students' challenges in learning visual programming. For example, (Tsai, 2019) emphasized that prospective mathematics teacher students' main problem is their difficulty in understanding basic concepts such as sequences, conditions, and loops, which is also the main obstacle in this research. (Medeiros et al, 2019) Also revealed that difficulties in syntax, lack of motivation, and heavy course load due to ineffective teaching methods were common challenges, which aligns with this research's findings. In addition, research from (Paredes-Velasco et al., 2024) showed that prospective mathematics teacher students' failure in visual programming was caused by prospective mathematics teacher students' negative perception of programming and lack of motivation; in his research, Paredes-Velasco used creative methods such as TutoApp to overcome these problems. This issue is also relevant to the finding that internal factors such as dislike for programming are significant barriers. These similarities suggest that the results of this research not only support but also enrich previous findings by providing more systematic recommendations to overcome the obstacles faced by prospective mathematics teacher students in visual programming.

▪ CONCLUSION

The conclusions from this research suggest that visual programming presents several challenges for prospective mathematics teacher students, particularly in understanding the basics of programming, including code structure, syntax and debugging. In addition, the application of programming in the context of numeracy and mathematics is also a significant obstacle. Prospective mathematics teacher students face difficulties in connecting mathematical concepts with practical programming implementations. These obstacles are compounded by internal issues, such as negative perceptions and dislike of programming, which inhibit their motivation to learn and develop in this field. In addition, the heavy course load, with many topics to cover in a short period and unstructured teaching methods, exacerbates this condition.

In response to these findings, this research shows the importance of strengthening the basic understanding of programming through directed and repeated practice so that prospective mathematics teacher students can overcome technical difficulties. In addition, there is a need to design more systematic and structured learning methods that allow prospective mathematics teacher students to learn gradually to understand programming concepts better. Innovations in teaching approaches, including visual aids that support practical understanding, are also important to facilitate learning.

This research suggests that teaching visual programming should be implemented with a more structured and systematic method, as well as adjusting the allocation of learning time so that prospective mathematics teacher students can understand the basic concepts in depth. Efforts are also needed to increase prospective mathematics teacher student motivation through a more enjoyable and relevant approach to reduce negative perceptions of programming. This research hopes to contribute to developing a mathematics education curriculum that is more adaptive to technological developments and prospective mathematics teacher student needs and encourage the improvement of the quality of programming teaching that is more effective in supporting the numeracy learning process.

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