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Structural Analysis and Typology of Postgraduate Students' Perceptions regarding Mathematics Learning

Mohamad Rif'at[1]*, Nurfadilah Siregar[2], Dona Fitriawan[2]
[1*,2,3]Program Studi Pendidikan Matematika, Universitas Tanjungpura
Jalan Prof. H. Hadari, Pontianak, Indonesia
[1*]mohammad.rifat@fkip.untan.ac.id; [2]nurfadilah.siregar@fkip.untan.ac.id;
[3]donafitriawan@fkip.untan.ac.id

ABSTRAK

Pandangan peserta didik program magister tentang matematika penting dikaji karena akan mempengaruhi cara mereka mengajar matematika. Tujuan penelitian adalah mengeksplorasi struktur keyakinan dan bagaimana perkembangan yang menggunakan pendekatan berbeda untuk mempromosikan pengaruh positif di kalangan mahasiswa. Subjek penelitian yaitu 269 mahasiswa Program Magister Pendidikan Matematika di UNTAN Pontianak yang juga bekerja sebagai guru. Instrumen pegumpulan data berupa kuesioner dan tes pemahaman konseptual. Analisis data dilakukan terhadap komponen pokok dari 63 item mengenai 'pandangan matematika'. Hasil penelitian menunjukkan inti pandangan tentang matematika terdiri dari tiga unsur yang berkaitan erat yaitu keyakinan tentang bakat diri sendiri, kesulitan, dan kenikmatan atau kesukaan terhadap matematika. Selain itu ditemukan juga bahwa pengetahuan konten spesifik matematika guru dan calon guru meningkat secara signifikan selama kuliah.

Kata Kunci: Keterampilan mengajar; Keterampilan professional; Pendidikan guru; pendidikan matematika program magister; Teori pedagogis.

ABSTRACT

Master's program students' views about mathematics are important to study because it will influence the way they teach mathematics. The aim of the research is to explore the structure of beliefs and how they develop using different approaches to promote positive influence among college students. The research subjects were 269 students of the Mathematics Education Masters Program at UNTAN Pontianak who also worked as teachers. Data collection instruments include questionnaires and conceptual understanding tests. Data analysis was carried out on the main components of 63 items regarding 'views of mathematics'. The research results show that the core view of mathematics consists of three closely related elements, namely beliefs about one's own talents, difficulties, and enjoyment or liking for mathematics. In addition, it was also found that teachers' and prospective teachers' mathematics-specific content knowledge increased significantly during college.

Keywords: Teaching skills; Professional skills; Teacher education; Mathematics education master's program; Pedagogical theory.

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1. INTRODUCTION

The competencies and views of mathematics education master's program students (who are mathematics teachers) have deep significance, because they teach mathematics to students. Negative views can seriously interfere with their mathematical abilities while in the classroom or as a teacher, unless they can overcome their anxiety or can find constructive strategies. Meanwhile, various efforts to promote a positive view of mathematics have often proven to be partially or partially successful (Awoniyi & Amponsah, 2023; Greensfeld & Deutsch, 2022; Orozco-Guzm á n et al., 2020; Raikhelgauz, 2022; Woodward et al., 2018)

In the last 3 decades, especially in the 1990s and 2020s, there has been a lot of research in mathematics education regarding negative views. These views stem from various factors, including misconceptions about negative numbers, declining student affect, and systemic inequities in educational contexts (Atweh et al., 2012; Gagatsis & Alexandrou, 2022; Pepin & Son, 2015; Skovsmose, 2012; Tuohilampi, n.d.; Zan & Di Martino, 2008) . Examples are group intervention programs to detect and overcome conceptual errors (Fang & Liu, 2019) or studies of groups linked to educators' awareness of students' difficulties applying and manipulating an algebraic structure (Veith et al., 2022). However, in discussions regarding educators' views on mathematics lessons, not many people know students' perceptions through a study. Analysis based on the Fennema-Sherman self-confidence scale shows that 22% of educators have low self-confidence in mathematics (Hannula et al., 2005). Similar problems have been identified from graduates of several universities in Indonesia (Liljedahl & Oesterle, 2020).

Until now, researchers do not know much about the views of educators and students regarding mathematics in typical classroom situations. It is clear that there are differences between the main views. For example, in discussing an error, there may be a better opportunity for learning to progress (Dresel et al., 2024; Kaur & Toh, 2019).

A structural and typical review of master's program students' views on mathematics refers to ways to understand master's program students' thoughts and perceptions about the subject of mathematics, as well as how these perceptions and understandings are shaped by their academic experiences. In general, master's program students' views regarding mathematics can be divided into two main categories: positive views and negative views. Positive views include the perception of mathematics as an interesting, important and useful subject in many fields, while negative views include the perception of mathematics as a subject that is difficult, confusing and not useful in everyday life.

Structural review refers to organizing students' views about mathematics within a larger conceptual structure. In this case, students' views about mathematics can be linked to their understanding of certain mathematical topics and concepts, and how these concepts are related to each other. A typical review, on the other hand, covers general patterns or trends in master's program students' views of mathematics. This may include patterns in perceptions of types of mathematics problems, the best approaches to learning mathematics, or the use of technology in mathematics learning.

Understanding the structural and typical overview of master's program students' views on mathematics can help teachers understand their students' perspectives and develop more effective approaches to mathematics teaching that can increase students' understanding and interest in this subject. The view of mathematics has a structure so that it can be differentiated towards different objects, namely 1) mathematics education, 2) oneself, and 3) social context (Eynde et al., 2002). With regard to the social context, (Eynde et al., 2002) found that the role and function of an educator is an important subcategory of himself. This is a spectrum of individual views that mathematics is very broad, and when grouped into groups that influence each other. For example, (Benfer, 1989) stated individuals indeed determine their own cognitive rules, forming quasi-logical structural systems that guide their understanding and interactions. This process is influenced by social constructs and individual experiences, leading to diverse cognitive frameworks . The views of students and educators about mathematics are the most basic, a psychological belief at the surface and depth (Eynde et al., 2002; Hannula, 2006; Karakose et al., 2023). According to Eynde et al., (2002) these beliefs can change the view of mathematics in an essential way.

The theoretical approach by educational psychology research groups is to apply negative expertise theory. This theory states that the view and typical "mistake" is a process or fact that does not conform to the norm. That is, mistakes are necessary to sharpen an individual's ideas and can be compared with examples and refuted counterexamples. So, it's not enough to know what is right, nor what is wrong. Because, otherwise, it would be impossible to identify where truth ends and where error begins. From this point of view, it is necessary and negative skills to complement the knowledge of right facts and processes from wrong thereby complementing positive skills (Zaccone & Pedrini, 2019; Zan & Di Martino, 2008)

Mistakes are critical to the acquisition of negative views. To use errors in a productive way, according to Metcalfe (2017), Ownsworth (2018), and (Dresel et al., 2024) requires individuals who are able to realize, analyze and correct the view, for example that someone uses mistakes to develop further prevention strategies. The negative view theory with the positive role of errors is in line with the constructivist view, while the behaviorist approach avoids mistakes and tries to emphasize only success, even though it is also recognized that mistakes are necessary and unavoidable learning opportunities.

Master's program students' views on mathematics can be analyzed through structural and typical reviews. A structural review involves analysis of the structure of students' thinking about mathematics, while a typical review covers the general views held by master's program students regarding mathematics.

2. METHOD

This research refers to data collected from 269 master's program students (already mathematics teachers in schools). Two questionnaires were planned to measure their mathematical confidence and initial competence entering the educational program. The 'mathematical outlook' indicator consists of items generated in a qualitative study regarding their mathematical beliefs, including a 10-item self-confidence scale from the Fennema-Sherman mathematical attitudes scale (Fennema & Sherman, 1976),a four-item 'success orientation scale' (Hannula et al., 2016) and background information on success in mathematics and experience as a teacher. The ability test contains 12 basic level mathematics tasks. Four tasks measure conceptual understanding and eight tasks measure numeracy skills. Questionnaire from a 60-minute comprehensive exam.

Analysis was carried out on the principal components of the 63 items regarding 'views of mathematics'. The topic 'experience as a teacher' is tailored to sufficient experience to answer the questions. The researcher chose to use the maximum likelihood method with direct oblim rotation and examined a number of different solutions (Hannula et al., 2005). When a principal component solution is found, the component structure is analyzed. Then, the correlation between components and the effects of the main variables were calculated: gender, subjects and lecturers appearing in the Mathematics Education Masters Program FKIP UNTAN Pontianak. After extraction of the principal components, a cluster analysis of the data was made to discover the profile of master program students (different teachers). For cluster analysis, the researcher chose 8 main components of the subject's views on mathematics as variables for grouping, Euclidean squared distance as a measure, and the Ward method for determining clusters.

3. RESULT AND DISCUSSION

a. *Principal Component Analysis*

In this analysis, the researcher chose to use data from ten research instruments created, and produced only high alpha values for those components (Table 1). Two of them only contained two items and did not include further analysis.

Table 1. Ten Main Components of Students' Views on Mathematics

Part Number	Component Name	Many Items	Alpha Cronbach
A1	I'm not that talented in math	8	0,91
A2	I work hard and diligently	5	0,81
A3	My work environment is encouraging	3	0,83
A4	Bad experience teaching mathematics	8	0,84

Part Number	Component Name	Many Items	Alpha Cronbach
A5	I feel safe as a mathematics teacher	4	0,74
A6	I can do well in mathematics	4	0,80
A7	I like mathematics	8	0,91
A8	Mathematics is difficult	6	0,78
A9	Mathematics is counting	2	exclude
A10	Im motivated	2	exclude

b. *The structure of students' views about mathematics*

Pay attention to the correlation between the eight components of analysis (Figure 1), observing that three components are closely related and form the core of master's program students' views on mathematics. This core consists of three aspects of a person's general attitude towards mathematics. The first aspect (A1) focuses on beliefs about the self, the second aspect (A8) on beliefs about mathematics, and the third aspect (A7) on a person's emotional relationship with mathematics. Around this core there are five factors, each of which relates primarily to the core and some secondary ones also relate to each other. Encouraging work environments (A3) had only a small effect on core views, whereas poor teaching experiences (A4) were more related to core views, as well as persistence (A2) and insecurity as a mathematics teacher (A5). Core also has a strong relationship with future expectations (A6), which may differ from factor A1 because as an element effort has a greater role in it and diligent (A2). Male students have higher self-confidence regarding their aptitude in mathematics (A1). However, there are no gender differences in students who like mathematics (A7) or consider mathematics to be difficult material (A8). Female students have a more critical image of mathematics lecturers (A4). From the regression analysis, gender accounted for 20% of the variation in views of mathematics. The structure is presented in Figure 1.

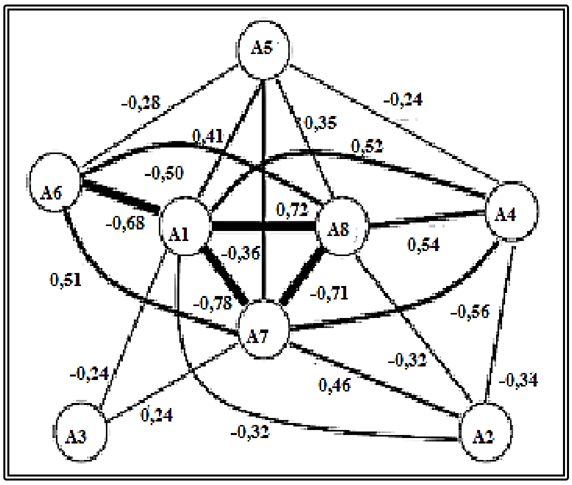

Figure 1. The structure of students' views about mathematics. Connection weights are Pearson correlations. The eight factors are depicted in Table 1

As assumed, courses in the master's level mathematics education study program have influenced students' views about mathematics (Hannula et al., 2005). Those who had studied more advanced mathematics in secondary school had higher self-confidence regarding their aptitude (F1). They also liked mathematics more (F7), but both groups found the subject equally difficult (F8). Those who had studied more advanced pathways (a lot) were less critical of their lecturers (F4) and received less encouragement from the school environment (F3).

However, the paths in Figure 1 show no influence on self-views of working hard (A2), even though advanced courses are generally seen as requiring more work or study (Reyes, 2019). From the regression analysis, elective courses accounted for 15% of the variation in views about mathematics. In this case, gender differences for elective courses also show an interaction effect between gender and courses, it was found that the interaction was not significant.

Students who achieve good learning outcomes in mathematics have a positive view of themselves and mathematics (Mapolelo & Akinsola, 2015). Ratings correlated significantly with students' own views of them as talented (A1) and as hard workers (A2), as well as their enjoyment of mathematics (A7), and views that mathematics is difficult subject matter (A8). The correlations obtained are low (weak), but still significant between women with a positive view of each lecturer (A4) and the opportunity to do well in mathematics (A6). All effects of ranking were more clearly measurable among female students and those who had studied more advanced mathematics courses at secondary school level (the ability to solve college entrance selection questions or equivalent Olympiad questions). From the regression analysis it was found that course ranking (basic, intermediate and advanced) contributed 12% of the variation in views about mathematics.

c. *Cluster analysis from students' views*

In cluster analysis, the three cluster solution separates students into groups based on the essence of their views on mathematics, namely: negative, neutral, and positive views. In completing the six clusters, each was placed into two groups, mainly based on the incentives of the work environment and their own views as hard workers (Figure 2).

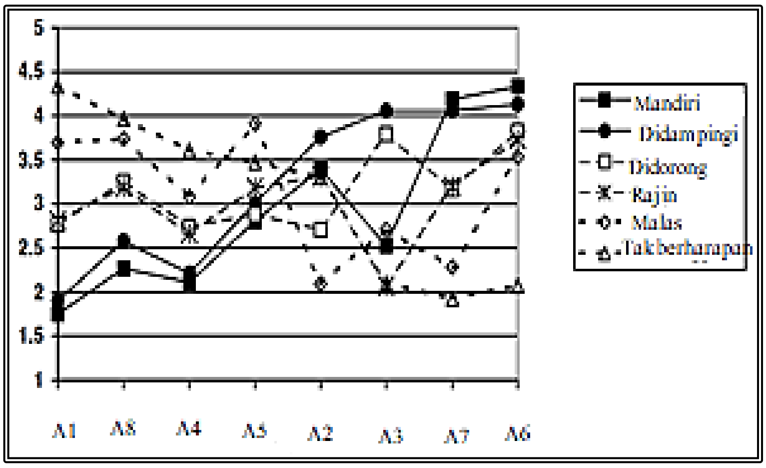

Figure 2. Six clusters of students (mathematics teachers) according to their views on mathematics

Positive outlook contains a view of oneself as an individual who is talented in mathematics and hardworking, mathematics is seen as easy and fun, a lecturer has a good memory, and self-confidence as a teacher and student in a master's program in mathematics education. The two subsets of this positive outlook include:

1. Independence (21%): Students who have the most positive outlook among all, they work quite hard even though the environment encourages their individual initiatives
2. Mentored (22%): Students receive very good assistance from the study program and this group is very hard working

Neutral view is the middle group on most dimensions. This student has moderate self-confidence about his own talents and does not like mathematics. The two groups of parts are:

1. Driven (18%): Students in this group are driven from the work environment, but do not work hard. They still doubt their abilities as mathematics teachers (even though they already have degrees in mathematics education).
2. Diligent (18%): Students in this group get the least encouragement from the work environment, but work quite hard.

Negative view includes a view of oneself as having no talent, not liking mathematics, the view that mathematics is difficult, a negative view of a lecturer, and a lack of confidence as a mathematics teacher. The two subgroups are:

1. Lazy (18%): Students in this group have less extreme negative views compared to other negative categories. They worked less hard and were the most careful of all groups in teaching mathematics.
2. Hopeless (4%): This group of students is the most extreme in their negative views. They are not pushed out of the work environment, even though they work hard. These students differ from all other clusters in that they do not believe they can learn mathematics.

Furthermore, students who have studied advanced mathematics seem to be in the encouraged group, while those who have studied it a little are in the diligent group. The gender factor is not statistically significant according to the distribution of students in different clusters, but because there are fewer male students, the researcher cannot conclude that gender is another insignificant factor (Kadarisma et al., 2019; Maier et al., 2021). Clusters also differ in test results and math rankings, with success being associated with more positive views. Clusters also differ in motivation, those with positive views have higher motivation and 'lazy' students have lower motivation compared to other clusters. However, clusters did not differ in teaching experience or age.

4. CONCLUSION

Studying the structure of beliefs, researchers found that the core of views about mathematics consists of three closely related elements: beliefs about one's own talents, difficulties, and enjoyment or likes of mathematics. The results of this study support the view that although emotions are correlated with beliefs, they are a separate aspect of a person's view of mathematics.

The three underlying variables: gender, course choice and rank are correlated with many variables, explaining some of the corresponding variation. It is interesting that, while gender differences were found in self-confidence, researchers did not find such differences in liking or accepting that mathematics is difficult. With these words, it is meaningful to separate the different aspects of the positive view of mathematics. Female students view themselves as more hard working and diligent than males.

Students fall into three main categories. Some have a positive (43%), neutral (36%) and negative (22%) view of mathematics. Each category is divided into two sub-categories mainly based on how much encouragement they receive from the work environment and how much level of hard work they have demonstrated. Some students who have a negative view are serious about their failures and have shown hard work and still failed. As a consequence, they already believe they cannot learn mathematics.

Through the use of multiple regression analysis, researchers found that the specific mathematics content knowledge of teachers and prospective teachers increased significantly during college. Additional analyzes showed that mathematics content knowledge, personal excellence, and mathematics teaching outcome expectations also increased during the course. While personal excellence was significantly correlated with content knowledge, a student's level of personal excellence did not significantly predict the content knowledge growth experienced over semester to semester. Likewise, students' pedagogical knowledge did not significantly predict growth during college. In addition, the relationship between personal excellence and content knowledge growth and the relationship between pedagogical knowledge and content knowledge growth were not moderated by their cognition.

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AUTHOR BIOGRAPHY

Dr. Mohamad Rifat

He is a Senior and Teacher Educator at the Universitas Tanjungpura, Pontianak, West Borneo. He was appointed lecturer in the university in 1988 and went on to pursue his magister and doctor in mathematics education at the UM Malang and UPI Bandung. He was appointed as Senior Assistant Professor in 2004. He is passionate about teaching and learning mathematics and the development in the schools and in the higher education settings.

Dr. Nurfadilah Siregar, M.Pd.

She is a Lecturer in Department of Mathematics Education, Graduate School, Universitas Tanjungpura, Pontianak, Indonesia. She was graduate in Universitas Negeri Medan in 2009, then continue her study in Universitas Pendidikan Indonesia for magister and doctor. Her research focuses on mathematics teaching and learning, self-determination in education, technology in leaning mathematics.

Dona Fitriawan, M.Pd.

Born in Metro city in May 11th 1989. He is lecturer in Department of Mathematics Education, Univresitas Tanjungpura. He was graduate in Universitas Muhammadiyah Metro and continued his master degree in mathematics education in Universitas Sebelas Maret. His research focuses on technology in leaning mathematics, high order thinking, and media teaching and learning.