Teacher Education and Professional Development on The Influence of Teacher-Student Relationships on Mathematics Problem-solving

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ABSTRACT

In this article, we uncovered aspects that students consider when learning to solve mathematical problems. The purpose of this study is to examine students' real experiences with mathematics problem-solving. We examine the method through which students learn to solve mathematical problems in order to develop Higher-Order-Thinking skills. Additionally, this study discusses the pedagogical consequences of contact between teachers and students during mathematical problem-solving. The cognitive and affective components are the factors that decide issue solutions. We investigated the lived experiences of 45 students in solving a mathematical problem using descriptive phenomenology research. As a result, we base our findings on current concerns in education and teacher professional development in order to better understand the influence of teacher-student relationships on mathematics problem-solving.

KEYWORDS: Mathematics Problem solving, Teacher Education, Professional Development, Pedagogy, Colaizzi, Phenomenology

1 INTRODUCTION

The primary goal of mathematics instruction is to increase students' problem-solving ability, which is a lofty aspiration. Analysis, interpretation, reasoning, evaluation, and forecasting are some of the most important abilities in life, and they require the ability to think critically (Wurdinger & Qureshi, 2015). The ability to solve problems is a necessary component of all mathematical curriculum (Singer et al.,2015). Furthermore, when dealing with Mathematics, problem-solving can create an environment that mimics real-world situations, allowing students to hone their skills in addressing difficulties in everyday life (Aydoğdu & Keşan, 2014). People are confronted with larger and more complex difficulties as a result of the world's expressive technical and scientific advancement. It is necessary to find and construct appropriate answers to these issues.

According to teachers, students' anxiety over mathematics is a common occurrence in their classroom. Mathematics is a subject that many of them either despise or like depending on their mood. It has been shown that emotions play an essential role in the learner's learning process when it comes to completing arithmetic problems (Hannula, 2015). One in ten dislike mathematics in general, and specifically the problem-solving process, and claim that it is "too difficult" for them. Students avoided mathematics as a result of these beliefs, and their mathematics performance worsened as a result (Taylor & Graham 2007).

Mathematics teaching is identified as one of the strategies to enhance critical thinking among students. Improving critical thinking among students is one of the competences required by the 21st-century generation (Brucal et al, 2019). Additionally, mathematics teachers have been working with students to strengthen their ability to solve mathematical problems. When it came to solving a math problem, teachers used a variety of ways to meet the needs of their students. However, students continue to struggle when it comes to completing a math issue (Fauziah, 2020). As a result, it is vital to identify the instructor and student characteristics that influence arithmetic problem-solving challenges (Agustyaningrum et al, 2021). In light of this, the researcher ponders this important subject, which provides in-depth self-realization. "When solving a math issue, do teachers apply the students' favorite teaching strategies? Is the effort made by teachers commensurate with the needs of students?"

The purpose of this study, we will look at students' actual experiences with mathematics problem-solving in the classroom. We examine the method through which pupils acquire the ability to solve mathematical problems in order to develop Higher-Order-Thinking skills necessary for success. This study also considers the pedagogical implications of contact between teachers and students while students are engaged in mathematical problem-solving activities.

2 METHODOLOGY

A descriptive phenomenological technique was used to describe a person's actual experiences in an attempt to improve daily experience by extracting meaning from the details of it (Wassler & Kuteynikova, 2020). Before, it was used to investigate and relate people's lived experiences, which is still the case today (Christensen et al, 2017).

Through interviews with students, descriptive phenomenology research allows the researcher to gain an understanding of how students see their own techniques of solving mathematical problems. It has been suggested that phenomenological investigation may be considered a source of evidence that goes beyond current understanding and, as a result, can lead to deeper and more fruitful findings.

Researchers submit a request letter to the institution's administration prior to conducting the study. Following the approval of the request, all participants were informed and volunteered to participate in the study.
Students' experiences with mathematics problem solving were investigated, recorded, and analyzed in this study. Through a Semi-structured Interview, we investigated the lived experiences of forty-five (45) students in solving a mathematics problem. The information was gathered through in-depth, open-ended interviews. It was done one-on-one with the students, with follow-up questions to guarantee we got rich replies by capturing multiple facets of their lived experiences and limiting socially desirable responses (Hendricks, 2017). The interview began with the following question: What is your experience with solving arithmetic problems? The success of phenomenological investigations, according to Colaizzi, is dependent on focusing questions on each participant's lived experiences. On the basis of the data provided by the respondents, follow-up questions were asked (Colaizzi, 1978).
A digital audio recorder and field notes were used in the research. All information stated verbally during the interviews was recorded using an audio recorder. During the interview, field notes were also used to record the emotional indicators presented by the participants. The following data processing processes were described in detail: After the study's purpose, all notes and data from the audio were transcribed.
To evaluate the transcribed material, we employed Colaizzi's phenomenological technique. Transcriptions were created while listening to the audios. It is a phenomenological data analysis approach that reveals an active strategy for obtaining the respondents' life experience descriptions (Sanders, 2003). It requires examining data and selecting key statements, which are subsequently formed into meanings.
The respondents' words were used to extract themes and subthemes, which were then condensed using the Colaizzi method's seven steps to yield broader thoughts and ideas. By employing pseudonyms to de-identify the data, confidentiality was maintained throughout the transcription process (e.g. Student 1, Student 2,..., Student 45). To decrease the risk of personal information being released, this was done after the interview.
Theoretically, themes from subgroups with commonalities should emerge. These established themes were to be evaluated and confirmed using Exploratory Factor Analysis in accordance with Matsunaga's concept of "How to Factor-Analyze Your Data Correctly: Do's, Don'ts, and How- To's" (Matsunaga, 2010) and Hair's concept of "Multivariate Data Analysis" (Hair, 1998). This statistical technique is used to reduce enormous amounts of data to a smaller number of fundamental components, and it has since become the most frequently utilized teaching tool for students when dealing with arithmetic problems. For the 2019-2020 academic year, a new group of 200 students from various year levels at a non-STEM middle school explored further into sixty aspects of these themes. There were 114 female students (57%) and 86 male students (43%) with twenty percent (20%) from Grade 7, 22.5 percent (22.5%) from Grade 8, 17.5 percent (17.5%) from Grade 9, and 40 percent (40%) from Grade 10. One hundred and twenty-seven students (63.5 percent) scored below average, 48 students (24 percent) scored average, and 25 students (12.5 percent) scored above average, according to the results.

3 RESULTS AND DISCUSSION

The statements of the 45 respondents were transcribed in order to generate themes. In the seven phases of the Colaizzi method, four themes emerged: affective aspects such as feelings and self-efficacy, as well as social factors such as group learning activity and the relationship between the teacher and the students. The statements were grouped together based on their commonalities, which resulted in the formation of subthemes, as seen in the following table.

Table 1. Themes and sub-themes obtained from data analysis.

Theme	Sub- theme
Sentiment	❖ Positivity ❖ Anxiety ❖ Regret
Personality	❖ Self-reliance ❖ Self- motivation ❖ Self- assurance
Group Learning Activity	❖ Group discussions ❖ Collaborating in Groups
Teacher-Student Relationship	❖ Teacher's Guidance ❖ My teacher, my mother

The data in the table above demonstrates that student sentiments had a role in the teaching-learning process. Positive and negative sentiments are experienced by all problem solvers, and these feelings might have an impact on their solution process. Emotions are a critical component of the problem solver's ability to self-regulate (Hannula, 2015). The results of the current study revealed that students experienced emotional distress when confronted with a mathematical difficulty. There was a sense of disappointment with regard to the subject matter present. During the observations, some students expressed frustration with their lack of acquired skills, which was noted by the observers. Based on their previous experience, they were unsure whether or not they could come up with a workable method that would generate the correct response. They were apprehensive, which may have led in them becoming discouraged about the topic. Findings from the study demonstrated that their emotional attributions to their perplexity, fears, and uncertainties are a contributing factor to their academic shortcomings.

However, several students claimed that they are capable of understanding the concepts and are willing to collaborate with their peers, which is a positive development. Their confidence and self-esteem are enhanced when they work as a team. As can be seen, practically all of the students prefer to participate in group activities rather than working independently. When participating in group conversations, the vast majority of participants overcome their fear and feel less intimidated because there is no emotional barrier that prevents them from expressing their opinions. As a result, individuals are able to complete the task successfully and increase their self-confidence (Azimova, 2020).

Students have also expressed their belief that understanding mathematical problem solving is dependent on their subject teachers. They were more motivated to learn if their teacher was comfortable to talk to and knowledgeable about the topic matter. This is especially true if their subject teacher is similar to their mother, who has guided them during the entire period of time.

Some students felt confident in their ability to complete a maths task on their own. They were determined to use their own initiative to discover solutions to the mathematical challenges that they were confronted with. According to Bandura, this is referred to as self-efficacy, and it refers to the process of actualizing an individual's ability or skills (Bandura & Walters, 1977). The following table (Table 2) contains samples of forty-five student's narratives organized according to the themes and their associated subthemes, as determined using the Colaizzi technique of analysis.

Table 2. Themes and Sub-themes and Example of Narratives

Themes and Sub- themes	Examples of Narratives
Sentiments	
❖ Positivity	❖ For me, solving mathematical problems is a pleasurable experience...." – (Student 24) ❖ "I'm glad my teacher thought my work was worthwhile." - (Student 11)
❖ Anxiety	❖ "In regards to the subject, "I'm feeling apprehensive." - (Student 32) ❖ "I am afraid of numbers" – (Student 3) ❖ "I am apprehensive about sharing my response... ❖ I'm having second thoughts about my responses". –(Student 44)
❖ Regret	❖ "I was disappointed when my answer was incorrect.". – (Student 27). ❖ "I'm disappointed if my grade is low." – (Student 15)
Personality	
❖ Self-reliance	❖ "In my opinion, it is preferable to solve problems on my own". (Student 21) ❖ "I'm capable of managing myself..." – (Student 7)
❖ Self- motivation	❖ "I am inspired when our teacher gives us the freedom to do whatever we want." - (Student 18) ❖ "I'm am encouraged to establish my own learning objectives.". (Student 2) ❖ "I am inspired to conduct research on the subject." – (Student 34)
❖ Self- assurance	❖ "I am confident in my answers during the quiz..." - (Student 18) ❖ "I believe that problem solving is simple... ❖ "I feel confident in my ability to pass this topic." – (Student 4)
Group Learning Activity	
❖ Group discussions	❖ "I learn a lot when we discuss our lessons with my classmates"- (Student 38) ❖ "I easily understand the topic when we discuss it by groups."- (Student 44)
❖ Working with the Group	❖ "I enjoy solving mathematical problems specially when we work it by group" – (Student 40) ❖ "Me and my classmates are working together to answer our assignments"- (Student 5)
Teacher-Student relationship	
❖ Teacher's Guidance	❖ "Our teacher guided us in our lessons…"- (Student 15) ❖ "I love my teacher because she guided me…" – (Student 27) ❖ "I need teacher's guidance for me to understand

	the lesson." –(Student 33)
❖ My teacher, my mother	❖ "My teacher is like my mother". –(Student 11) ❖ "I like the way our teacher treat us, she treat us like her children… she care for us". – (Student 14) ❖ "…easy to talk to, like my mother." – (Student 21)

The researcher developed a 7-point Likert - scale from 1-Strongly Disagree to 7-Strongly Agree based on the topics and subthemes that were generated (see Table 2). A total of 200 participants answered 60 Likert-scale questions to record their experiences in mathematics problem solving.

Both Kaiser's eigenvalue and the scree test were used to determine how many significant factors were evident (Kaiser, 1960). In order to proceed with the analysis using the Exploratory Factor Analytic technique, the following should be done as ad-hoc or assumptions (Hair, 1998).

Table 3.KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.820
Bartlett's Test of Sphericity	Approx. Chi-Square	4882.504
	Df	1596
	Sig.	.000

Kaiser Meyer Olkin (KMO) and Bartlett's tests were performed to measure the strength of the relationship between the variables in Table 3. Kaiser proposed for a beginning point of 0.5 (KMO value) (which was only marginally approved) (Kaiser, 1960). According to the table above, the KMO Measure of Sampling Adequacy is.820, which is more than 0.5, meaning that the responses produced by the samples are "adequate" (Table 3).

In addition to the Pearson correlation coefficient, the Bartlett's Test can be used to determine the strength of a link between two variables. It was proved in the same Table that the Bartlett's Test of Sphericity was statistically significant, indicating that factor analysis was required. As a result, it does not function as an identity matrix (Table 3).

Table 4.Total Variance Explained

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	11.983	19.971	19.971
2	4.294	7.157	27.128
3	2.975	4.958	32.086
4	2.304	3.840	35.926
5	1.999	3.332	39.258
6	1.839	3.065	42.322
7	1.696	2.827	45.149
8	1.513	2.521	47.670
9	1.482	2.471	50.141
10	1.411	2.352	52.493

11	1.365	2.275	54.767
12	1.272	2.120	56.887
13	1.258	2.096	58.984
14	1.221	2.035	61.018
15	1.108	1.847	62.866
16	1.100	1.833	64.699
17	1.017	1.696	66.395

Eigenvalue reflects the number of extracted factors.

Using the information in Table 4, it was discovered that the Statistical Product and Service Solution (SPSS) extracted factors and the cumulative percentage were both 66.395 percent. The variance was explained by these 17 factors to the tune of 66.395 percent. All of the remaining factors were found to be non-significant. The scree plot was used to help researchers find additional potentially significant features. Examining the results of Cattell's scree test (see Figure 1) confirmed that rotating these seventeen components was suitable, as the bend in the elbow happened after each of the seventeen factors was rotated.

The scree plot is a graph of eigenvalues against all factors that is used to estimate the number of elements that should be removed from the data. The point on the curve where the curve begins to flatten is the point of interest. The curve begins to flatten between the ages of 18 and 19, as shown on the graph. It should be noted that factors 18 and onwards have an eigenvalue less than 1, implying that the model must have either sixteen or seventeen components.

As a primary output of the principal components analysis, the rotated component matrix (with variables in rows and components in columns) shown in Figure 2 is considered to be the most important result. It comprises estimates of the correlations between each of the variables and each of the estimated components of the relationship. The figure shows that the variables i16, i31, i32, i33, i34, i35, i36, i37, i39, and i44 are loaded in component 1. Component 2 is heavily loaded with the items 1, 3, 5, 6, 8, 14, and 18. Component 2 is also heavily loaded with the items 1, 3, 5, 6, 8, 14, and 18. The elements loaded in component 3 are i46, i47, i48, i49, i50, and i56. Figure 2 contains a listing of all of the variables loaded from components 4 through 17.

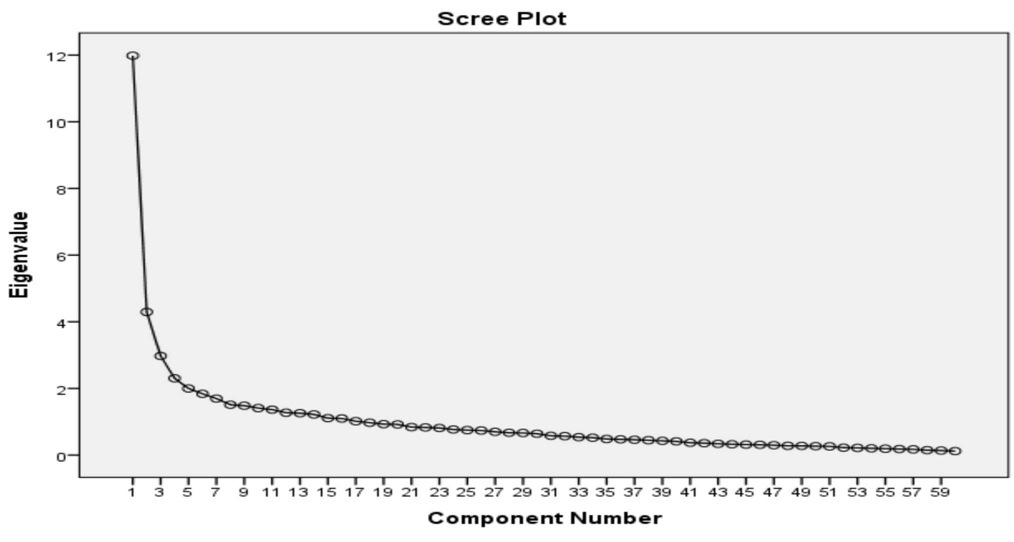

Figure 1. Scree Plot with 60 elements based on Principal Component Analysis (PCA)

The loading of the components/factors was done in a size-based manner. The factor loading with the highest strength at the top was 0.739, while the factor loading with the lowest strength at the bottom was 0.410. (Figure 2).

	Component																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
i34	.739																
i36	.724																
i35	.719																
i31	.670																
i39	.667																
i32	.666										-.413						
i33	.654																
i37	.646																
i16	.547														.434		
i44	.538																
i6		.790															
i5		.767															
i1		.730															
i8		.649															
i18		.596															
i14		.422															
i3		-.411															
i50			.698														
i46			.689														
i56			.645														
i47			.583														
i49			.531														
i48			.448	.404													
i59				.605													
i58				.594													
i57				.591													
i55				.527	.462												
i54				.474			.445										
i26					.662												
i25					.595												
i27					.533												
i12					.530												
i24					.435												
i60						-.678											
i30						.669											
i28						.551											
i29						.496											
i20							.754										
i38							.723										
i53								.620									
i11								.510									
i52								.481									
i22									.744								
i23									.677								
i4										.735							
i7										.425							
i10											.587						
i19											-.436						
i17																	
i13												.820					
i21												.453					
i45													.750				
i40													.424				
i51																	
i41																	
i2														.746			
i42															-.786		
i15																.709	
i43																	.755
i9																	.410

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 22 iterations.

Figure 2: Matrix of Rotated Components

Figure 2 demonstrates that the variables i16, i31, i32, i33, i34, i35, i36, i37, i39, and i44 are loaded into component 1 by the variables i31, i32, i33, i34, i35, i36, i37, i39, and i44. Component 2 is heavily loaded with the items 1, 3, 5, 6, 8, 14, and 18. Component 2 is also heavily loaded with the items 1, 3, 5, 6, 8, 14, and 18. Component 3 contains the entries i46, i47, i48, i49, i50, and i56. In addition, all other variables from components 4 to 6 were loaded.

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
i34	.739					
i36	.724					
i35	.719					
i31	.670					
i39	.667					
i32	.666					
i33	.654					
i37	.646					
i16	.547					
i44	.538					
i6		.790				
i5		.767				
i1		.730				
i8		.649				
i18		.596				
i14		.422				
i3		-.411				
i50			.698			
i46			.689			
i56			.645			
i47			.583			
i49			.531			
i48			.448	.404		
i59				.605		
i58				.594		
i57				.591		
i55				.527	.462	
i54				.474		
i26					.662	
i25					.595	
i27					.533	
i12					.530	
i24					.435	
i60						-.678
i30						.669
i28						.551
i29						.496

Figure 3: Six-factored Rotated Component Matrix

As a result, i32 is heavily loaded on components 1 and 11, and i16 is heavily loaded on components 1 and 15 (cross-loading). In addition, i48 is heavily loaded on components 3 and 4, i54 is heavily loaded on components 4 and 5, and i55 is heavily loaded on components 4 and 5. (see Figure 2).

We must compare the item loading tables after the rotation; the one with the "clearest" component structure (Figure 3) has the best fit to the data, with minimal (only 1) item cross-loadings and no factors with fewer than three items (in fact, there are 10, 7, 6, 6, 6, 6 and 4 items for the 6 components, respectively). The six-component item loading tables (Figure 3) will obviously be employed (Osborne et al, 2014).

Based on the findings, the theme for Factor/Component 1 items was 'Teacher-student relationship,' the theme for Factor/Component 2 items was 'Sentiments', the theme for Factor/Component 3 and 4 items was 'Personality' and the theme for Factor/Component 5 and 6 items was 'Group learning activity.' In the correlation matrix, these six components initially accounted for 66.395 percent of the total variance (Table 4). Furthermore, when determining variables, the percentage of total variation explained is critical, and 66.395 percent is the acceptable minimum (Hinkin, 1997). If the loadings were weak (.40), items with cross loadings (i.e., those that load considerably on two or more factors) were eliminated. Finally, the factors were given names depending on the information included in the factor items. In conclusion, an exploratory factor analysis of the 60 Likert-scale items yielded a four-factor basic structure that may be understood.

4 CONCLUSION

One of the successful method for students to learn how to solve arithmetic problems was to have their teacher help them while they practiced on their own time. Students must be guided by their teachers in order to improve their mathematical abilities. It is easier for them to make a positive impact when they understand that their teachers support students via learning activities while taking their feelings into consideration and adapting educational opportunities to match their needs. The study found that the interaction between the teacher and the students during learning activities, which is a social component, is the most highly associated element that impacts the mathematical performance of students, as evidenced by the results.

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