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# Adaptive and Supportive Resilience: Pre-Service Mathematics Teachers' Strategies for Managing Geometric Proof Challenges

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**Abstract**

This narrative inquiry study explored the challenges encountered by pre-service mathematics teachers in geometric proofs, their resilience strategies, and the impact of these strategies. Eight participants were purposefully selected to share their stories through semi-structured interviews. Data were analyzed using systematic thematic analysis. Trustworthiness of findings was established through credibility, transferability, dependability, and confirmability. Identified challenges included cognitive, conceptual, pandemic-driven, instructional strategies, and personal barriers. Resilience strategies encompassed self-driven growth and motivation, integrated support network, and effective learning and teaching strategies. These strategies led to individual growth and learning and resilience-driven teaching. Findings suggest that difficulties in geometric proofs are widespread among pre-service mathematics teachers, aggravated by the COVID-19 pandemic. Adaptive and supportive resilience were crucial to overcoming challenges. Comprehensive support is needed to strengthen the resilience among these teachers. Future research should explore whether pre-service teachers are adequately equipped to teach geometric proofs and examine their teaching practice experiences.

**Keywords:** COVID-19 pandemic, Geometry, Pre-service teachers

## 1. Introduction

The Philippine Mathematics Curriculum Framework emphasizes the development of critical thinking and problem-solving skills among Filipino learners, while also laying a strong foundation in essential concepts and life skills needed in basic education (TIMSS Encyclopedia, 2019). Among its key content areas are geometry, numbers and number sense, measurement, patterns and algebra, and probability and statistics.

Geometry, in particular, has played a vital role throughout history and continues to be significant in a wide range of disciplines today (Parreño & Marpa, 2019). It is also associated with expanded academic and career opportunities (Aboagye et al, 2021). Despite its importance, many studies reveal that students find geometry challenging, especially in areas such as proving and reasoning (Aboagye et al, 2021; Cirillo & Hummer, 2019; Kpotosu et al, 2024; Maarif et al, 2019; Parreño & Marpa, 2019; Winer & Battista, 2022).

For Filipino learners in particular, these struggles are well-documented. Recent results from the Programme for International Student Assessment (PISA) show that the Philippines ranked near the

bottom in mathematics, with the country's average score falling below the OECD average (OECD, 2023). UNESCO research further highlights that Filipino students face significant challenges with abstract concepts, particularly in geometry and algebra (Picaza et al, 2024).

The preparedness of teachers, particularly pre-service mathematics teachers (PSMTs), is critical for effective geometry instruction. Manero and Arnal-Bailera (2021) and Haavold et al (2024) underscored significant gaps in PSMTs' reasoning and proof competencies, with many struggling to meet the expected standards for teaching secondary-level geometry.

Specifically, a study conducted at one state university in the Philippines underscores these difficulties. Abing et al. (2024) found that mathematics education students exhibited only an average mastery of geometry, which did not meet the expected standard. While their performance improved as they advanced through higher levels, it still fell short of the required competency.

This issue is particularly concerning for PSMTs, who will soon be responsible for shaping the future of mathematics education in the country. Understanding how these future educators approach the proving process is crucial (Manero & Arnal-Bailera, 2021). Equally important is addressing the challenges they face with geometric proofs and equipping them with a deep understanding of the subject. Exploring the strategies these PSMTs use to overcome their struggles can provide valuable insights. With this knowledge, teacher educators can offer more targeted support, empowering them to become competent and effective mathematics teachers capable of inspiring the next generation of learners.

Hence, this study examined the challenges faced by PSMTs in geometric proofs and the resilience strategies they use to manage these challenges. Specifically, the study aimed to identify (1) the challenges encountered by PSMTs in geometric proofs, (2) the resilience strategies they employ to address these challenges, and (3) the impact of these strategies on their learning and teaching practices.

## 2. Methodology

### Research Design

This qualitative study employed narrative inquiry in conducting an in-depth examination of the PSMTs' lived experiences, offering rich, contextualized insights into their challenges, resilience strategies, and the impact of these strategies, particularly in geometric proofs.

Participants

Eight PSMTs were selected via purposive sampling based on two criteria: (a) officially enrolled mathematics education students (1st semester, 2024-2025); and (b) scheduled for practice teaching deployment (2nd semester, 2024-2025).

The participants were also chosen considering STEM background and geometry grades. The sample comprised four STEM graduates (12.5% of total pre-service mathematics teachers, N = 32) and four non-STEM graduates, each with the highest and lowest geometry grades.

Participants signed informed consent forms, indicating voluntary participation and acknowledging understanding of ethical considerations (Groenewald, 2004). The forms outlined: participation details; research purpose; procedures; potential risks and benefits; voluntary participation; right to withdraw; and, confidentiality protection measures.

### Research Instruments

An interview schedule, consisting of ten questions was utilized for data gathering. It was validated by an expert panel of five members, including two mathematics experts, an English language expert, a narrative inquiry specialist, and a psychology expert.

The researcher also maintained detailed field notes throughout the study, capturing nonverbal cues such as facial expressions, gestures, pauses, and silences. Audio recordings of interviews, taken with informed consent, were made using a digital recorder and a mobile phone to ensure precise transcription. To protect confidentiality, participants were assigned unique codes, and all audio recordings were securely stored on a password-protected computer and deleted after data analysis.

**Data Collection**

Individual semi-structured interviews (Adhikari, 2021; Subedi, 2021) were used to gather data, providing a detailed understanding of participants' experiences (Mueller, 2019).

Following Adhikari's (2021) guidelines, each participant underwent 2-3 interviews which ensured data saturation. To enhance comfort and encourage spontaneous responses, interviews were conducted in the participants' vernacular language, as recommended by Liamputtong (2020). Translations into English were later verified by a bilingual expert to ensure accuracy in data analysis.

To ensure trustworthy findings, this study adhered to four standards: credibility, transferability, dependability, and confirmability (Ahmed, 2024; Rose & Johnson, 2020; Stahl & King, 2020; Williams & Kimmons, 2022; Younas et al., 2023).

Credibility was ensured through triangulation by combining interview transcripts, observations, and field notes to identify patterns, reduce bias, and improve accuracy. Transferability was demonstrated through thick descriptions of PSMTs experiences, categorized into thematic clusters, enhancing generalizability as suggested. Dependability was established by meticulously documenting approaches, data collection techniques, and analytical procedures, supplemented by a comprehensive audit trail, facilitating potential replication. Finally, confirmability was enhanced through member checking, where participants verified interview transcript accuracy.

Data collection ceased upon reaching saturation, defined as the point where no novel data or themes emerged (Naeem et al., 2023) or where categories yield no additional insights (Nigar, 2020). This phenomenon confirms data adequacy (Creswell, 2013; Sarfo, 2021; Subedi, 2021).

**Data Analysis**

Interview data were analyzed using systematic thematic analysis, a structured six-step method developed by Naeem et al. (2023) ensuring comprehensive understanding, consistency, and replicability.

The process began with transcript creation and data familiarization, where the researcher reviewed interview recordings, transcribed them verbatim, and selected key quotes to capture diverse participant perspectives.

Next, keywords were identified by analyzing transcripts, observations, and field notes to pinpoint recurring terms and patterns that reflected participants' experiences.

In the coding phase, concise phrases or words (codes) were assigned to segments of data to summarize key ideas and themes.

These codes were then grouped into meaningful categories during theme development, revealing patterns and relationships that addressed the research questions.

The conceptualization stage involved defining and refining emerging concepts, focusing on understanding social patterns and aligning them with the study’s objectives.

Finally, a conceptual model was developed to synthesize the findings, connect them to existing theories, and highlight the study's contributions to knowledge.

## 3. Results and Discussion

### Results

Through a rigorous analysis of the interviews, four key themes were identified as challenges, three as resilience strategies, and two as the impact of these strategies. These themes are summarized in the following table.

| Categories | Themes | Codes |
|---|---|---|
| Challenges in Learning and Teaching Geometric Proofs | ▪ Cognitive and Conceptual Barriers | ✓ Understanding and retaining information<br>✓ Problem-solving and analytical thinking<br>✓ Visualizing and expressing learning |
| | ▪ Pandemic Driven Barriers | ✓ Learning modalities and connectivity issues<br>✓ Time management and personal responsibilities |
| | ▪ Instructional Strategies Barriers | ✓ Engaging and motivating students<br>✓ Adapting content to diverse needs |
| | ▪ Personal Barriers | ✓ Individual teaching challenges |
| Adaptive and Support Practices for Resilience | ▪ Self-Driven Growth and Motivation | ✓ Self-regulation techniques<br>✓ Emotional adaptability<br>✓ Time management and organization<br>✓ Growth mindset<br>✓ Recognition and reflection |
| | ▪ Integrated Support Network | ✓ Teamwork<br>✓ Mentorship<br>✓ External Guidance |
| | ▪ Effective Learning and Teaching Strategies | ✓ Independent learning<br>✓ E-learning<br>✓ Collaborative learning<br>✓ Technology integration<br>✓ Differentiated instruction<br>✓ Activity-based teaching |
| Impact on Growth and Teaching | ▪ Individual Growth and Learning | ✓ Learning improvement<br>✓ Emotional balance and confidence<br>✓ Smooth and fulfilling learning |
| | ▪ Teaching and Mentorship | ✓ Resilient Teaching Practices<br>✓ Empowering Students' Resilience |

### Discussion

### Challenges in Learning and Teaching Geometric Proofs

PSMTs encountered the following challenges in geometric proofs: cognitive and conceptual barriers, pandemic-driven barriers, instructional strategies barriers, and personal barriers.

### Cognitive and Conceptual Barriers

Cognitive and conceptual barriers involve difficulties in understanding and retaining information, challenges with problem-solving and analytical thinking, and struggles with visualization and effective expression in learning. These findings align closely with the challenges highlighted in various studies. Difficulties in understanding and retaining information mirror struggles with recalling and applying geometric postulates and theorems (Parreno & Marpa, 2019). Problem-solving and analytical thinking challenges are compounded by the inherent complexity of geometry topics, as noted by Kpotosu et al (2024), and by obstacles in applying concepts and principles to solve problems (Noto et al., 2019). Struggles with visualization and effective expression are particularly evident in the inability to create accurate sketches or diagrams for conjectures (Maarif et al, 2019) and in difficulties transitioning sound oral reasoning into formal written proofs (Winer & Battista, 2022).

PSMTs manifest difficulty in understanding and retaining information through confusion, cognitive

overload, and difficulty applying learned principles. Participant 3 described, “Geometric proof is a mix of frustration, confusion, and accomplishment for me. Sometimes, I feel overwhelmed by the number of theorems I had to memorize.” Participant 7 explained, “It was a challenge for me memorizing statements so I tend to get overwhelmed when I need to mention theorem or principle to support my claims. Similarly, Participant 5 noted, “I’m also confused what to use to come up with a proof because I sometimes forget the essential concepts.” Finally, Participant 2 admitted, “I cannot remember well how geometric proof is used…and I easily forget information on how [it] is done.”

Meanwhile, Participants 3, 5, and 7 notably reported problem-solving and analytical challenges. Participant 3 shared, "I often struggle to determine the logical connections in geometrical problems that require proof…” Participant 5 compared it to solving a puzzle, saying, "It was like getting into a puzzle with hidden clues. You have to know the different axioms, postulates, and formulas to solve a problem. With a lot of concepts to consider, I’m having a headache." Participant 7 humorously added, "Like miss, I can tell whether the two triangles are similar, but I can’t explain why, hahahahaha."

Additionally, PSMTs face challenges in visualizing and expressing geometric proofs. This shared difficulty was particularly evident among participants 2, 3, and 4. Participant 4 noted, "Honestly, I find geometry a difficult subject, especially visualization of figures." On similar manner, Participant 3 stated, "I had a hard time creating an accurate representation of the conjecture using proper notation. Additionally, writing the conjecture in the form of symbols and formulas was also quite difficult." Further, Participant 2 asserted, "Maybe one of the challenges I've encountered is understanding geometric proof since until now I cannot remember well how geometric proof is used or in which way do you provide factual evidences (reasons) to support the claims (statements)."

**Pandemic-Driven Barriers**

This theme encompasses the challenges faced by PSMTs during the COVID-19 pandemic, particularly learning modalities and connectivity issues and balancing time management with personal responsibilities. The findings corroborate with El Mourabit et al. (2023) and Mannah-Blankson and Asiseh (2021) who highlighted the challenges pre-service teachers faced during the transition to digital platforms, such as limited access to technology, poor internet connectivity, and unfamiliarity with online learning tools, which were significant barriers to effective learning.

PSMTs' testimonies further illustrate these struggles. In terms of learning modalities, Participant 1 shared, "For me, miss, about learning modality...because during that time it was still pandemic, and most of our activities had to be done online or modular." Similarly, Participant 6 noted, "My experiences during my geometric proof are not quite good because of online learning."

Meanwhile, relative to internet connectivity issues, Participant 4 expressed, “During the first week, it was difficult for me learning geometry due to internet connection,” and Participant 2 added, “And sometimes I can’t attend our online classes. Mostly because of the signal, Miss.” Participant 8 elaborated further, “I can't focus on our lessons during discussions due to an internet connection. We are not able to discuss our lessons properly because of internet connection problems that may occur during online class, as well as it's difficult to cope with online and modular classes.”

Additionally, Salakhova et al (2022) found that home learning environments played a crucial role in interfering with students' learning during the pandemic, a challenge that was further compounded by Barot et al (2021), who highlighted the difficulties students faced in managing time between personal responsibilities and academic demands. The present study's findings resonate with these observations, as PSMTs faced similar barriers.

Participant 4 explained, “During the first week it was difficult for me learning geometry due to time management because I was a working student.” Similarly, Participant 3 noted, “…not to mention my obligations at home and online meetings which happen simultaneously sometimes,” and Participant 2 shared, “I was taking care of my mother who was bedridden. I was alone and I need to do all that needed to be done.”

**Instructional Strategies Barriers**

This theme highlights the perceived challenges PSMTs will face in keeping students engaged and motivated when learning geometric proofs. This finding reflects the study by Parreño and Marpa (2019), which recommends that geometry teachers should continuously motivate their students to foster interest in mathematics, particularly in geometry. Such motivation can help address engagement challenges and support improved learning outcomes in this subject area.

PSMTs attribute these challenges to a lack of student interest, feelings of intimidation, and difficulty recognizing the relevance of geometric proofs. These views align with earlier research showing that engagement is a complex issue involving cognitive, behavioral, affective, and social dimensions (Jansen et al, 2023). Additionally, a lack of interest in mathematics contributes to learning difficulties (Zain & Rahayu, 2023). Aguilar (2021) underscores that students' reluctance toward mathematics is often rooted in self-perceived low-content knowledge and understanding, fostering negative attitudes that trace back to early education. Furthermore, Juman et al (2022) emphasizes that disinterest in geometry negatively impacts students' learning experiences.

Participant 7 remarked, “I think the challenge is teaching geometric proofs to students without interest in geometry.” Similarly, Participant 3 observed, “Some students may feel intimidated when we talk about proofs since it involves logical reasoning, and others may struggle to see their importance.” These factors collectively make sustaining student motivation and engagement a notable challenge. As Participant 4 stated, “The specific challenge would be how to make geometry inside the classroom engaging.” Additionally, Participant 8 highlighted, “And also it may be difficult for me to maintain students' engagement and motivation.”

PSMTs also anticipate challenges in adapting teaching content and methods to address the diverse needs of students. This corresponds to the findings of Yin and Chai (2020), who observed that addressing the individual needs of every student is often insurmountable challenge, highlighting the dilemmatic and complex nature of catering to diverse learning needs. Rogers (2023) further accentuates that diversity within classrooms introduces a range of challenges for teachers, making it essential to balance inclusivity with effective instructional strategies.

Participant 5 shared, “I think the different learning styles of the students, like some students can easily grasp concepts or information while others need thorough explanation about a certain topic.” Furthermore, Participant 3 pointed out, “Addressing the diverse needs of students is probably one. Hence, ensuring they understand the basics before diving into complex proofs could be challenging.”

**Personal Barriers**

This theme deals with the individual teaching challenges of PSMTs. Some of them identified personal difficulties in understanding and performing geometric proofs as a significant barrier. The study of Haavold et al (2024) supports this finding. They asserted that teachers have difficulty integrating proof in their mathematics instruction due to both narrow beliefs about proofs and limited understanding of proofs. For instance, Participant 6 shared, “I think explaining to the students the information related to geometric proof in detail is a challenge because I have personal difficulties on how to perform geometric

proof."

Additionally, managing nervousness, anxiety, and timidity were identified as obstacles, particularly in maintaining effective communication and interaction with students. This finding corroborates that mathematics anxiety in initial teacher education is a growing issue that reflects on teacher quality (Ersozlu et. al., 2022) Participant 2 noted, "Also, one of the challenges is communication with the students since I am not interactive. I also easily get nervous if I am in front of a crowd."

**Resilience Strategies in Managing Geometric Proof Challenges**

Based on the stories of PSMTs, despite facing many challenges, they showed resilience by using strategies like self-driven growth and motivation, integrated support network, and applying effective learning and teaching strategies.

**Self-Driven Growth and Motivation**

This reflects the resilience strategies that PSMTs employ, focusing on self-regulation techniques, emotional adaptability, time management and organization, growth mindset, and recognition and reflection.

Self-regulated learning refers to the ability of learners to control and direct their learning process (Landa et al, 2024). PSMTs used techniques like frequent practice, repetition, creating routines, and setting purposeful goals to overcome learning challenges and foster progress.

In particular, Participant 3 underlined the role of frequent practice in addressing challenges with geometric proofs, stating, "Overcoming such hurdles require frequent practice, so what I would do is to try and practice everything after discussion." Similarly, Participant 2 shared a repetitive approach, explaining, "I just continue the same process and repeat them again to ensure that I remember the information and not forget them until such time I completely understand them." Other participants highlighted tailored routines and goal-setting. Participant 4 described the strategy as prioritizing weak areas during free time: "My strategies during that time Maám so that I can recover from the challenges I encountered in geometry was if I have free time, I prioritized studying subjects or lessons where I weak at like geometry. That's my routine always until I was able to adjust." Finally, Participant 7 underscored the motivational power of setting a purpose: "I also set a purpose why I'm doing a certain task to be motivated throughout."

Meanwhile, according to Bagdziuniene et al (2023) emotional adaptability helps teachers manage challenges, enhancing emotional well-being and teaching effectiveness. The narratives of PSMTs provide insight into their specific strategies for staying motivated. These include listening to music, positive self-talk, taking breaks, self-affirmation and rebuilding oneself as practical approaches. For instance, Participant 4 shared, "Whenever I get frustrated and get stuck in one or some problems, one important strategy I used is taking a break or listening to music while at it and revisiting the proofs later on with a fresh perspective. I also practiced positive self-talk to keep myself motivated." Similarly, Participant 5 emphasized the role of self-affirmation, "I just keep saying that I can do it just like other students." Participant 1 reflected on a deeper sense of purpose, saying, "And I realized I need to keep going because I have a lot of dreams for my family, and I need to rebuild myself."

Effective time management and organization, on the other hand, entails planning and controlling how time is spent on various tasks, with key components such as setting clear goals, prioritizing activities, organizing tasks, and managing stress (Australian Christian College, 2019). PSMTs confirmed this through strategies such as setting aside dedicated study time, prioritizing challenging subjects like geometry, and taking a step-by-step approach to their studies. Participant 4 recalled, "My strategy during

that time Maám so that I can recover from the challenges I encountered in geometry was if I have free time, I prioritized studying subjects or lessons where I weak at like geometry." Participant 1 emotionally recollected, "One day at a time miss until face-to-face classes were resumed. Each day I continued to seek for motivation and tried to meet new people. Then slowly I recovered." Similarly, participant 8 recounted, "I was able to overcome these challenges slowly and gradually.

Consequently, a growth mindset is a belief that abilities are not static but can be improved through effort, learning, and perseverance (Hogarty, 2022). This mindset shapes how individuals approach challenges, process failures, and grow from their experiences. PSMTs exemplified this perspective by acknowledging their weaknesses and employing resilience strategies such as determination, patience, persistence, and striving to give their best effort. This is consistent with Schaffner's (2020) assertion that individuals who face challenges with dedication are more likely to achieve academic success.

Particularly, Participant 7 emphasized giving the best and acknowledging areas of weakness, stating, "One of my resilience strategies is giving my best output/performance as much as possible. I also acknowledged my weaknesses and worked on in improving them." Similarly, Participant 3 highlighted the importance of persistence, saying, "I won't stop until I get it done correctly. Sometimes it would take hours to finally comprehend everything." Further, the same participant stressed, "Pause, take a break and do it again. And if you still messed up despite trying so many times, you have to be stubborn enough and try again." Participant 5 echoed a similar sentiment, saying, "... and never give up no matter how difficult the subject is."

Finally, recognition and reflection, as Crane et al. (2019) suggest, strengthen resilience by promoting self-awareness, acknowledging personal strengths and weaknesses, and encouraging alternative problem-solving approaches. PMSTs reflected these strategies by celebrating small wins, acknowledging their sense of achievement, and reaffirming their personal motivations. Participant 3 shared "I also gave myself small rewards for the effort, like treating myself to a favorite snack, watching Kdramas or anime, reading or just taking a break after feeling burnt out from studying and doing all the modules/output." She further added, "Solving them gave me a sense of achievement." Furthermore, she expressed, "Remembering my 'WHYs' really kept me motivated during those times 'til now… and giving myself—family a good life."

Participant 1 also shared how personal motivations helped him stay focused. He said, "Seeing my parents also pushed me to keep going. But somehow if I'm alone I tell myself 'This is so tiring.' Then, I also pushed myself to go on because I realized I am wasting time. And given that I have a scholarship I realized that I couldn't afford to lose my scholarship. And I realized I need to keep going because I have a lot of dreams for my family and I need to rebuild myself."

**Integrated Support Network**

This theme underscores that resilience flourishes when individuals can depend on supportive networks, including teamwork, mentorship, and external guidance. Research supports the importance of social bonds in fostering resilience. Marler et al (2021) noted that social acceptance and connection significantly enhance students' motivation to learn and their sense of belonging. Furthermore, social support has been found to strengthen psychological resilience by guiding individuals toward healthier coping mechanisms (Barwal & Cherian, 2024; Cao et al, 2024).

Participants shared that seeking help from peers, friends, or mentors played a critical role in overcoming challenges. Participant 1 stated, "I ask help with my classmate with some concepts that confuse me." Similarly, Participant 4 mentioned, "I was able to overcome these challenges slowly and gradually with

the help of my former math teacher and also my friends who are fond of shapes." Participant 5 added, "To overcome the challenges, I ask help from my friends how the problems are solved for me to be enlightened about the topic."

Peer collaboration was also highlighted as instrumental in learning geometric proofs. Participant 3 expressed, "…collaborating with my classmates to clarify confusing parts," while, Participant 4 emphasized, "I've learned a bit in geometry because it was more on group activity."

In addition, the role of teachers in inspiring and guiding students was evident. Participant 4 shared, "I opened up to my former math teacher that I have difficulty in dealing with geometry. When she learned about it, she explained unclear concepts to me." Similarly, Participant 1 noted, "The impact of a teacher also pushed me to go on. There are teachers who are very inspiring. They don't only teach lessons from the books but also teach life lessons."

**Effective Learning and Teaching Strategies**

This theme highlights the strategies PSMTs use in learning geometric proofs and how their education programs prepare them to teach these concepts effectively in the future.

In terms of learning strategies, the narratives of the PSMTs pointed out independent learning and e-learning as key techniques that facilitated their understanding of geometric proofs during the COVID-19 pandemic disruption.

Independent learning involves self-directed study where students take responsibility for their educational progress, exploring topics beyond classroom constraints. It fosters critical thinking, self-motivation, and adaptability by encouraging learners to set goals, seek resources, and apply knowledge in real-world contexts (Saad et al, 2024). Meanwhile, e-learning refers to digital education systems that provide flexible, on-demand access to learning materials. It allows students to learn at their own pace, accommodating diverse learning styles and promoting personalized learning experiences, making complex topics more accessible (LearningBOX, 2021).

Participants demonstrated resilience through self-directed strategies, such as searching for additional resources and practicing independently at home. For instance, Participant 2 shared, "And I also find examples and additional information," while Participant 6 added, "When it came to information, I searched on my own, which gave me a clear understanding of the topic we discussed." Similarly, Participant 3 noted strategies like "creating diagrams [and] rewriting theorems in my own words," showcasing proactive approaches to understanding geometric proofs.

Additionally, e-learning played a critical role in facilitating their studies. Many participants utilized digital platforms, including YouTube and Khan Academy, to access tutorials and supplementary materials. Participant 7 explained, "I watched videos from YouTube and other platforms for easy understanding," and Participant 5 mentioned, "To overcome the challenges, I do advance study like watching YouTube tutorials." Further, Participant 3 noted, "Reading materials on the net like Khan Academy also really helped a lot." Participant 8 similarly stated, "I watched different videos from YouTube about the lesson as well as sought different sources on the internet."

Further, the narratives of the PSMTs emphasized the support and guidance they received from their teacher education program through collaborative learning, technology integration, differentiated instruction, and activity-based teaching, which collectively built their confidence and creativity in teaching. These strategies align with the findings of Vale and Barbosa (2023), which highlight that collaborative work and mathematical communication enable the emergence of diverse strategies for solving tasks. Similarly, research by Motseki and Kakoma (2023) underscores the importance of

teaching approaches that prioritize student participation, noting that creating a participatory and collaborative learning environment is critical for fostering effective classroom interaction in mathematics. Additionally, Tukiman et al. (2024) suggest that interactive methods, such as educational games, can boost interest in mathematics and improve student engagement and proficiency.

All PSMTs shared that their teacher education program equipped them with essential content knowledge and key concepts in geometry. They also highlighted effective teaching strategies in their training.

For instance, Participant 4 shared, “They also emphasized teaching strategies and techniques that will facilitate active students. Also, they emphasized using technology in teaching mathematics. Lastly, they fostered a collaborative learning environment.” Participant 3 elaborated, “It has taught me to be creative and resourceful in my teachings by incorporating activity-based learning and making use of local teaching materials, manipulatives, and ICT for modeling.” Participant 8 echoed the importance of critical and creative thinking, adding, “Our teachers always challenge us to think critically and creatively in making different activities that catch the interests of our diverse students.”

**Impact of Resilience on Growth and Teaching**

This theme highlights how PSMTs’ resilience strategies not only facilitated individual growth and learning but also enhance teaching practices, fostering a resilient learning environment for students. These findings align with Fru-Ngongban's (2023) assertion that resilience positively influences learning achievement and with Zakaria's (2019) emphasis on its role in educational success. Similarly, Dwiastuti's et al (2022) study, which revealed that students with high resilience are more likely to maintain or improve academic performance, supports the results of this study. Furthermore, the findings resonate with Alarilla's (2024) observation that resilience fosters personal growth and well-being, including increased self-confidence, improved problem-solving skills, adaptability, and enhanced self-esteem following challenging life experiences.

**Individual Growth and Learning**

According to the PSMTs, their resilience strategies significantly supported their individual growth and learning. Participant 1 shared, “I could trace an improvement little by little in my study,” while Participant 2 noted, “I was able to slowly and gradually understand the process of information about geometric proof.” Participant 5 elaborated further, stating, “These strategies help me to overcome my difficulty in learning geometric proof, like I can easily understand the different problems given by our teacher.” Similarly, Participant 6 reflected, “These strategies impact my learning of geometric proofs to better understand and be an independent learner.” Participant 8 added, “These strategies helped me to improve my learnings and helped me overcome my difficulties in learning during the pandemic.”

In addition to learning improvements, PSMTs highlighted how their resilience strategies helped them achieve emotional balance and confidence, making their experience with geometric proofs smoother and more fulfilling. Participant 4 shared, “Like, I don’t feel nervous or afraid with geometry anymore because I have learned something which builds my confidence.” Participant 7 added, “I became more patient and dedicated in giving my best.” Similarly, Participant 3 emphasized, “These strategies helped me stay calm, determined, and focused, making the learning process more enjoyable and less stressful.”

**Resilience-driven teaching**

The impact of resilience extended beyond the learning achievements and personal growth of PSMTs, motivating them to inspire resilience in their future students through resilient teaching practices. According to ELC (n.d.), resilient teachers are exemplary role models, teaching students not only academic content but also how to remain strong and determined during challenging times. This

perspective aligns with Wang & Lo's (2022) assertion that teacher resilience is crucial in global education, as resilient teachers are essential for nurturing resilient learners (Inquirer.net, 2024).

Additionally, Walsh et al (2020) highlights that educators can foster resilience by integrating resilience teaching and training into their practices. This involves emphasizing core resilience concepts such as self-efficacy, reflective ability, and self-confidence, equipping both teachers and students to thrive despite challenges.

For instance, participant 3 detailed, "I'll use my personal experiences to teach my future student's patience, perseverance and persistence, I'll instill in their minds that struggling with geometrical proofs and other geometrical concepts is normal and can be overcome with great effort and frequent practice." Participant 4, further added, "Finally, I could improve the way they think and develop courage in facing challenges and opportunities like the way I did."

In addition, PSMTs collectively emphasized the importance of employing teaching approaches such as collaborative learning, differentiated and individualized instruction, and e-learning to support their students' resilience. Participant 1 highlighted the value of peer-based methods, stating, "My resilience strategies will influence my future teaching practices in a way that I would use those strategies in order for my students to understand the lesson. Peer tutoring or peer sharing is one great way to enhance students' learning." Similarly, Participant 2 shared, "I will support my students through different strategies. Like if my students can learn better if I deliver the information in detail and in a step-by-step manner, then I'll use the method or strategy that I used for myself."

Participant 7 further explained, "Just like how I extended my patience in learning geometry, I think I would be more patient in teaching the students geometry lessons in a detailed and step-by-step manner so that all of them can relate and catch up. Especially in dealing with inquisitive students, individualized teaching is needed."

Participant 8 elaborated, "My strategies can influence my future teaching practice, as they will help me seek other ways or methods to teach effectively and help students understand our discussions. Seeking different resources from the internet and watching videos on YouTube can help me develop and apply the skills I can learn from these platforms."

Overall, these accounts suggest that pre-service mathematics teachers feel well-prepared to teach geometric proofs. Participant 5 stated confidently, "My program has helped me build my confidence in teaching my students to master geometric proofs." Participant 4 concluded, "All of these would be a big help to us future educators in becoming effective teachers in the near future and will make us ready to inspire the new generations."

However, this is contrary to Alelaimat et al. (2020) who argued that teacher education programs need stronger curricula to better equip future teachers with the confidence and skills necessary to support students' learning effectively.

**Concluding Statement**

PSMTs encounter significant challenges in learning geometric proofs, regardless of their background in STEM or non-STEM fields, or their level of geometry proficiency. This suggests that geometric proof challenges are widespread among PSMTs.

These challenges often arise from gaps in their preparation for geometric reasoning and communication. The COVID-19 pandemic further intensified these issues, as disruptions to face-to-face learning created technological barriers, reduced student engagement, and necessitated rapid adaptation to online learning environments. These difficulties underscore the need to address such gaps effectively.

To manage these challenges, PSMTs adopted both adaptive and supportive strategies. Adaptive strategies, such as self-driven growth motivation, enabled individuals to overcome obstacles through independent effort. Supportive strategies, including mentorship and peer collaboration, provided critical external guidance and emotional encouragement. These approaches not only facilitated learning but also underscored the importance of resilience in addressing cognitive and conceptual barriers to understanding geometric proofs.

Recognizing these challenges, teacher education programs must prioritize the development of resilience strategies among PSMTs to prepare them for the complexities of teaching geometric proofs. Enhancing geometry proficiency through targeted instruction in reasoning, proof construction, and mathematical communication is essential. Moreover, integrating opportunities for peer collaboration, mentorship, and access to experienced educators can foster a sense of community and support. Programs should also strengthen independent learning practices and leverage e-learning tools to enable PSMTs to adapt to diverse teaching contexts.

The inclusion of collaborative learning, differentiated instruction, and technology integration within teacher preparation programs is particularly critical in equipping future educators to address the varying needs of their students. Embedding resilience training into these programs not only enhances teachers' ability to overcome their own challenges but also empowers them to inspire and guide students in navigating difficulties. By focusing on resilience and geometry-specific competencies, teacher education programs can ensure that PSMTs are well-prepared to deliver effective instruction and foster supportive, adaptable learning environments.

Considering the limitations of this study, future research should explore several key areas to improve PSMTs' preparation. Longitudinal studies can track how PSMTs' geometric proof skills develop over time and the impact of resilience-building strategies. Studies could also examine how resilience training frameworks could help build emotional intelligence and teaching effectiveness. Additionally, research into differentiated instruction will aid in preparing PSMTs to address diverse student needs. Finally, policy studies could focus on integrating these competencies into teacher certification standards, ensuring PSMTs are fully equipped to teach geometric proofs effectively.

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