The Relationship Between Mathematical Thinking and Resilience in Number Sequence Lesson Through Ethnomathematics Among Pre-service Primary School Teachers

Christiyanti Aprinastuti[1,2*], and *Maria Agustina* Amelia[2]

[1]Doctoral School of Mathematical and Computational Sciences, University of Debrecen, Egyetem tér 1, 4032, Debrecen, Hungary
[2]Primary School Teacher Education Study Program, Sanata Dharma University, Jalan Affandi, 55281, Mrican, Yogyakarta, Indonesia

Abstract. This research investigates the relationship between mathematical thinking and resilience in 31 pre-service primary school teachers, explicitly focusing on a number sequence lesson using ethnomathematics. Mathematical thinking, crucial for effective teaching, is a cognitive process that depends on overcoming challenges and is closely connected to resilience. By incorporating ethnomathematics, which integrates mathematics into cultural practices and real-world situations, the study examines how this approach supports the development of mathematical thinking and resilience. Participants were evaluated on their resilience and mathematical thinking during lessons. The findings revealed that the relationship between mathematical thinking assessment (MTA) and resilience scale of mathematics (RSM) using the Pearson Correlation test is $r_{MTA*RSM} = 0.116 > 0.05$. These results show no significant relationship between resilience and mathematical thinking. These results highlight the importance of including culturally relevant pedagogies like ethnomathematics in teacher education programs to better equip future educators for diverse classroom settings.

1 Introduction

Mathematical thinking is essential to successful teaching and learning in primary education [1]. Thus, it is also a crucial competency for pre-service primary school teachers (PPST). This construct is beyond mere comprehension of concepts, involving exploration, questioning, visualization, and problem-solving in diverse contexts [2]. These components are essential for future educators, as they need to understand mathematical concepts and facilitate students learning challenges [3], [4], [5], [6]. Stacey, Burton, and Mason [7] describe mathematical thinking as specializing, generalizing, conjecturing, justifying, and convincing skills. Specializing is a simple technique that everyone can use when they cannot proceed with a question. Generalizing moves from a few instances to making guesses about

* Corresponding author: christiyantia@science.undeb.hu

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

a broad class of cases. Conjecturing arises automatically by carrying out the familiar processes of specializing and generalizing. Justifying involves providing logical arguments or evidence to support a conjecture or solution. Convincing involves communicating reasoning to persuade others of the validity of a solution or argument.

Number sequence is a mathematical topic promoting these mathematical thinking skills. Research by Mor et al. [8] found that designing activities and tools that allow students to construct and share models of number sequences promotes mathematical thinking. That is also confirmed by Pasnak [9] because understanding number sequences leads to understanding mathematics concepts. In particular, pre-service primary school teachers should thoroughly understand number sequences because these fundamental concepts underpin essential arithmetic skills, pattern identification, and cognitive development [10],[11]. Number sequences can assist pre-service elementary teachers in linking additive and multiplicative structures in number sets [12], developing logical thinking, and understanding the fundamentals of mathematics [13].

However, it is essential to acknowledge that the competencies of PPST students differ from those of prospective mathematics educators. PPST has a background characterized by insufficient engagement with mathematics. So, resilience is essential for comprehending number sequence concepts. Mathematical resilience is the ability to overcome challenges and thrive in mathematics education, which is gaining recognition as a crucial factor for success. Resilience is significantly related to academic performance in mathematics [14]. Some research also explained that resilience is crucial for success in mathematics education [15]. Resilience is closely connected with cultural identity and how culture influences mathematical thinking, abilities, and learning trajectories. Then Owen [16] continues exploring how the cultural setting of mathematics enhances a teacher's identity as a mathematically thinking teacher. He concludes that an activity that links culture and school mathematics plays a role in building values and identities.

Numerous examples exist of real-life applications that integrate with the topic of number sequences. Cultural context is one of the relevant topics that resonates with students. Additionally, Yogyakarta, Indonesia, is characterized by rich traditional cultures. This context can be a starting point for learning mathematics, particularly in number sequences. Pangestuti and Prahmana [17] assert that the intersection of culture and mathematics represents a starting point of mathematics learning. In other words, ethnomathematics provides a cultural perspective for analyzing mathematical cognition by relating school mathematics to students' cultural and daily experiences, promoting their learning and resilience [18]. Ethnomathematics focuses on the contextual and cultural significance of mathematical topics, potentially improving comprehension and involvement. Integrating an ethnomathematics approach into number sequence courses can benefit primary school teachers in the early phases of their professional growth. This technique promotes both advanced mathematical thinking and the ability to solve pedagogical problems. In this study, we choose "sedekah bumi" (charity to the earth) traditional ceremony as a cultural context for several reasons: 1) this traditional ceremony is usually performed in Yogyakarta, Indonesia; 2) Students from outside the region are invited to learn about the culture in the area where they study; 3) the concept of number patterns that emerge in traditional ceremonies.

The interconnection of mathematical thinking, resilience, and cultural integration emphasizes a wide area for exploration within pre-service primary school teachers. Prior studies have examined the impact of culture on cognition and teacher self-perception [19], [16]; however, further emphasis should be placed on resilience within a context to enhance mathematical thinking in classes centred on number sequences. This study seeks to investigate two research questions: (1) is there a relationship between mathematical thinking and resilience of pre-service primary school teachers when engaged in a number sequence

lesson with cultural integration? (2) how do culturally integrated number sequence lessons support pre-service primary school teachers' mathematical thinking skills and resilience? This research aims to provide literature regarding the importance of integrating cultural context into mathematics education and its role in fostering resilience and mathematical thinking skills in future educators.

2 Research Methods

This study employed a mixed-methods approach, integrating quantitative and qualitative methods. While quantitative methods investigate the relationship between mathematical thinking and resilience within an ethnomathematics framework, the qualitative method investigates how culturally integrated number sequence lessons support mathematical thinking skills and resilience. The study involved 31 first-year pre-service primary school teachers in a private university in Yogyakarta, Indonesia. Participants were selected based on their enrolment in a required mathematics education course, including number sequence lessons. Informed consent was obtained from all participants, and the university granted ethical approval for this study. It was conducted in one meeting in 90 minutes in the middle of the semester. The participants were given a number sequence lesson through ethnomathematics. Then, they worked on mathematical thinking tests, resilience questionnaires, and open-form reflection.

We use a mathematical thinking assessment (MTA) instrument adapted from Mason and Stacey [7]. The assessment included tasks that required specializing, generalizing, conjecturing, justifying, and convincing skills. It was conducted at the lesson's end to measure students' mathematical thinking. The second instrument is the resilience scale for mathematics (RSM). The RSM was adapted from the Adversity Quotient (AQ) by Stoltz [20] and was designed to evaluate the participants' resilience in the context of mathematics learning. Venkatesh [21] also states that AQ is a scientifically grounded tool that can measure and strengthen human resilience. We adapted the questions to consist of 4 items as follows: (1) Realizing math is not as difficult as imagined, (2) Feeling challenged by math subjects, (3) Experiencing anxiety when receiving math assignments, (4) Preferring to copy friend's work on math assignments. Based on validation test data, the sig value (2-tailed) for Q1: $0.008 < 0.05$; sig value (2-tailed) for Q2: $0.006 < 0.05$; sig value (2-tailed) for Q3: $0.00 < 0.05$; and sig value (2-tailed) for Q4: $0.00 < 0.05$. Based on these data, the four aspects of RSM are valid. Instrument reliability testing was carried out using Cronbach's Alpha test. The obtained coefficient was 0.417. The r table value for alpha is 0.05, and n is 31, resulting in an r table of 0.355. The RSM instrument is reliable because Cronbach's Alpha value is $0.417 > 0.355$. The last instrument is an open questionnaire conducted to gain deeper insights into how culturally integrated number sequence lessons support pre-service primary school teachers' mathematical thinking skills and resilience. The method of data collection using a questionnaire was chosen because data on mathematical thinking and the resilience scale of mathematics for all research subjects will be obtained. Data collection was supplemented with reflection from students to obtain more in-depth data.

The MTA and RSM scores were analyzed using correlation analysis to explore the relationship between mathematical thinking and resilience. The study aims to determine the relationship between the MTA and RSM variables. The correlation test is used because the study wants to determine to what extent changes in the RSM variable affect the MTA variable. Correlation analysis can also identify whether there is a positive, negative, or no relationship. Before conducting a correlation test, a prerequisite test is conducted for the variables to be tested. The prerequisite tests conducted are 1) normality test, 2) homogeneity test, and 3) linearity test. If the prerequisite test is met, the next correlation test is carried out using the Pearson Product Moment method. Meanwhile, if the prerequisite test is not met,

the hypothesis test will be carried out using Spearman Rank Correlation. The open questionnaires were analyzed using a case study to examine the influence of cultural context on mathematical thinking and resilience among pre-service primary school teachers.

3 Result and Discussion

3.1 Result

Before we analyzed the correlation between mathematical thinking and resilience, we conducted normality and homogeneity tests. To find out the normality of the data, this research used SPSS 29 for the normality test. All research variables have a normal distribution using Liliefor significance correction. Based on validation test data, the sig value (2-tailed) for Q1: 0.008 < 0.05; sig value (2-tailed) for Q2: 0.006 < 0.05; sig value (2-tailed) for Q3: 0.00 < 0.05; and sig value (2-tailed) for Q4: 0.00 < 0.05. Based on these data, the four aspects of resilience are valid**.** The homogeneity test results using the Levene test show that Sig. on the RSM variables based on mean: 0.802 > 0.05 and Sig. based on trimmed mean: 0.785 > 0.05. Thus, it can be concluded that the RSM variables have the same variance or are homogeneous. The following prerequisite test was conducted: the linearity test. This research used SPSS 29 for the linearity test. The results of the linearity test between the MTA and RSM variables in the deviation from the linearity section obtained Sig.: 0.703 > 0.05. Based on these results using the ANOVA test, it can be concluded that there is a linear relationship between the MTA variable and the RSM variable. After all prerequisite tests, the t-relationship test was carried out with the following results: The correlation test was carried out on the MTA and RSM variables.

Hypothesis:
Ho: There is no relationship between the MTA variable and RSM ($r_{MTA*RSM} = 0$)
Ha: There is a relationship between the MTA variable and RSM ($r_{MTA*RSM} \neq 0$)

Based on the Pearson correlation test, Sig. (2-tailed): 0.116> 0.05. These results show no significant relationship between the MTA and RSM variables. The correlation coefficient results of 0.228 strengthen these results. Based on Table 1, the interpretation of the correlation coefficient means that the MTA and RSM variables have a weak correlation.

Table 1. Correlation Test

		MTA	RSM
MTA	Pearson Correlation	1	0.288
	Sig. (2-tailed)		0.116
	N	31	31
RSM	Pearson Correlation	0.288	1
	Sig. (2-tailed)	0.116	
	N	31	31

The qualitative data highlighted that participants felt more confident and enjoyed the lesson due to the culturally grounded approach to the lessons. This increased resilience was particularly noted in their willingness to tackle complex problems and reduce reliance on copying others' work. Key themes of thematic analysis in the open questionnaire included "cultural connection enhancing engagement (for example, as stated by S16, “learning is more interesting than before because it uses coloured stickers in culture context, which makes it more engaging") "reduction in math anxiety" (for example, as stated by S16 “I can learn mathematics easily without anxiety and it turns out mathematics is not always difficult”), and "increased confidence in problem-solving (for example, as stated by S12, “While working on ethnomathematics questions, I realized that cultural motifs contain mathematical elements, so I felt confident to do that”). These themes reinforce the finding that ethnomathematics significantly boosted resilience, even though it did not significantly impact mathematical thinking.

3.2 Discussion

This study examines the relationship between mathematical thinking and resilience in the context of an ethnomathematics teaching approach. The results show no significant correlation between better mathematical thinking abilities and the resilience of pre-service primary school teachers. The findings indicate that ethnomathematics influences resilience, offering significant insights for mathematics teaching. However, there is no correlation between cognition and resilience; this lack of relationship suggests that these two variables grow independently. Utilizing culturally aligned teaching approaches yields results comparable to Faradilah's research [22], indicating that mathematical resilience does not influence critical thinking. The slight rise in documented cognitive activity indicates that, while ethnomathematics may improve engagement and relevance, additional work is required to foster sophisticated mathematical thinking within the limited study period. Carrillo et al. [23] assert that high-achieving students enhance their cognitive abilities and resilience, suggesting a correlation between these two constructs. Improving thinking requires thinking logically, solving problems, and achieving significant progress; it may require much effort and various approaches. This is especially true when considering the important factors of the cultural environment. A substantial improvement in resilience highlights ethnomathematics' advantages in making mathematics more accessible and less intimidating for students. When participants approach mathematics from a cultural context, they express greater confidence and reduced anxiety. Qualitative data shows that cultural context can encourage attitudes toward mathematics for sustained engagement. As stated by Iqbal [24], ethnomathematics can promote a mathematical perspective for sustained engagement and achievement. The participants demonstrate resilience because of the connection between mathematical concepts and their cultural backgrounds. This result influenced learning to be more pertinent and less abstract. It is aligned with research highlighting the significance of responsive teaching in building student motivation and engagement [18]. Ethnomathematics situates mathematical problems into contexts that enhance student engagement and motivate them to confront challenges.

The results show that although ethnomathematics can contribute to increased resilience, more efforts may be needed to enhance mathematical thinking. For example, improving problem-solving skills and logical thinking within an ethnomathematical culture may be necessary. Additionally, research can investigate how various combinations of materials can enhance mathematical thinking and resilience. The research results show that culturally relevant mathematics education methods are crucial for fostering student resilience.

4 Conclusion

This study investigated the relationship between mathematical thinking and resilience in pre-service primary school teachers using the lens of ethnomathematics-based teaching. The findings indicate that there is no relationship between mathematical thinking and resilience among pre-service primary school teachers. It means that while ethnomathematics promotes resilience, it does not result in an improvement in mathematical thinking. These findings showed that improving resilience through culturally relevant training does not always result in enhanced mathematical thinking. As a result, educators should consider mixing ethnomathematics with other instructional strategies that focus more directly on the development of mathematical thinking and problem-solving abilities.

References

1. A.J. Bishop, Teachers' Mathematical Values for Developing Mathematical Thinking in Classrooms: Theory, Research and Policy (2008)
2. K. Devlin, Teaching mathematics as a way of thinking – not calculating. Eesti Haridusteaduste Ajakiri. Estonian Journal of Education. **9**, 33 (2021)
3. M. Abbas, A. Mahmood, M.M. Akhtar, Academic Resilience Among Post Graduate Students in the Universities of Islamabad: A Comprehensive Assessment. Spry Contemporary Educational Practices (2024).
4. M. Yousuf, A. Mahmood, S.M. Ishaq, A study to investigate the challenges of prospective teacher of mathematics facilities at university level (graduate). Spry Contemporary Educational Practices (2024).
5. D.L. Ball, The Mathematical Understandings That Prospective Teachers Bring to Teacher Education. The Elementary School Journal. **90**, 449 (1990)
6. M.A. Nicolás, M.C. Torremorell, M.P. Valls, Dificultades en conceptos matemáticos básicos de los estudiantes para maestro. International Journal of Developmental and Educational Psychology. Revista INFAD de Psicología. **1**, 419 (2016)
7. J. Mason, L. Burton, K. Stacey, Thinking Mathematically (Prentice et al., 2010).
8. Y. Mor, R. Noss, C. Hoyles, K. Kahn, G. Simpson, Designing to see and share structure in number sequences. The International Journal for Technology in Mathematics Education. **13**, 65 (2006)
9. R. Pasnak, K.L. Schmerold, M.F. Robinson, K.M. Gadzichowski, A.M. Bock, S. O'Brien, J.K. Kidd, D.A. Gallington, Understanding number sequences leads to understanding mathematics concepts. The Journal of Educational Research. **109**, 640 (2016)
10. S. Griffin, Learning Sequences in the Acquisition of Mathematical Knowledge: Using Cognitive Developmental Theory to Inform Curriculum Design for Pre-K–6 Mathematics Education. Mind, Brain, and Education. **3**, 96 (2009)
11. J. Olive, Children's Number Sequences: An Explanation of Steffe's Constructs and an Extrapolation to Rational Numbers of Arithmetic. The Mathematics Educator. **11**, 4 (2000)
12. R. Zazkis, P. Liljedahl, Arithmetic Sequence as a Bridge between Conceptual Fields. Canadian Journal of Science, Mathematics and Technology Education. **2**, 91 (2002)
13. J.L. Ferreira, A importância do ensino de sequências numéricas matemáticas: Estratégias e abordagens. RCMOS - Revista Científica Multidisciplinar O Saber (2024).
14. J.P. Rojas-Suárez, M. Vergel Ortega, H.J. Gallardo Pérez, Resilience in successful math and physics students. J. Phys.: Conf. Ser. **1587**, 012015 (2020), https://doi.org/10.1088/1742-6596/1587/1/012015

15. C. Xenofontos and S. Mouroutsou, Resilience in mathematics education research: A systematic review of empirical studies. Scandinavian Journal of Educational Research **67**, 1041 (2022)
16. K. Owens, The impact of a teacher education culture-based project on identity as a mathematically thinking teacher. Asia-Pacific Journal of Teacher Education. **42**, 186 (2014)
17. S. Pangestuti, R.C. Prahmana, F.A. Fran, Unlocking mathematical marvels: Exploring number patterns in the Rangku Alu traditional game. Jurnal Elemen (2024).
18. M. Rosa, D.C. Orey, Ethnomathematics: The Cultural Aspects of Mathematics (Etnomatemática: Os Aspectos Culturais da Matemática).
19. A. Mahmood, M.F. Othman, Y.M. Yusof, International Conference on Teaching and Learning in Higher Education (ICTLHE 2012) in conjunction with RCEE & RHED 2012: A Conceptual Framework for Mathematical Ability Analysis through the Lens of Cultural Neuroscience (2012).
20. P.G. Stoltz, Adversity Quotient: Turning Obstacles into Opportunities (1997).
21. J. Venkatesh, G. Shivaranjani, Adversity Quotient Profile: A Robust Assessment Tool to Measure Human Resilience. Asian Journal of Research in Social Sciences and Humanities. **6**, 412 (2016)
22. Faradillah, Ayu and Tia Humaira. "Students' Critical Thinking Skills on Algebraic Problems Through Mathematical Resilience." JPI (Jurnal Pendidikan Indonesia) (2021)
23. Carrillo, Martha Cecilia Santiago et al. "Mathematics, resilience and development of youth thinking." Journal of Physics: Conference Series (2019)
24. Nst, Muhammad Iqbal and Nanda Khairani Batubara. "The Importance Of Ethnomathematics In Education: A Systematic Literature Review." Proceedings of International Conference on Education (2024)