Journal of Educational Research and Evaluation
Volume 8, Issue 2, 2024, pp. 231-239
P-ISSN: 2597-422x E-ISSN: 2549-2675
Open Access: https://doi.org/10.23887/jere.v8i2.77501

How Can We Better Comprehend the Disposition of Elementary School Students towards Advanced Mathematical Thinking?

Nadya Dewinda Agustin[1*], Mohamad Syarif Sumantri[2], Arita Marini[3]

[1,2,3] Faculty of Education, Jakarta State University, East Jakarta City, Jakarta, Indonesia

ARTICLE INFO

Article history:
Received January 12, 2024
Accepted April 16, 2024
Available online May 25, 2024

Kata Kunci :
Disposisi matematika, berpikir matematis tingkat lanjut, matematika pendidikan dasar

Keywords:
Mathematics Disposition, Advanced-Mathematical-Thinking, Mathematics Elementary Education.

ABSTRAK

Metode pembelajaran matematika konvensional menekankan pada kecepatan dan ketepatan, menciptakan tekanan yang tidak perlu dan sering kali tidak akurat dalam mengukur prestasi anak. Penelitian ini bertujuan untuk membangun kerangka kerja, mengkaji secara sistematis wilayah afektif siswa khususnya disposisi matematis, dan menganalisis urgensi Advanced Mathematical Thinking (AMT). Penelitian ini merupakan penelitian komprehensif investigasi atau eksplorasi metode campuran dengan menggunakan triangulasi data. Subyek yang terlibat dalam penelitian ini adalah siswa sekolah dasar yang berjumlah 80 orang. Metode pengumpulan data yang digunakan adalah angket. Selain itu, penelitian ini menggabungkan pertanyaan-pertanyaan terbuka dan narasi acak yang menangkap sudut pandang peserta dalam pembelajaran matematika. Teknik analisis data menggunakan analisis deskriptif kualitatif dan kuantitatif. Hasil penelitian menunjukkan bahwa guru harus mempertimbangkan beragam kapasitas dan kendala kognitif, emosional, dan psikomotorik siswa selama proses pendidikan. Hal ini dapat dilakukan dengan menggunakan kegiatan dan metodologi pembelajaran yang tepat, seperti tugas individual dan pembelajaran eksploratif yang menyesuaikan dengan kemampuan siswa. Selain itu, penggunaan penilaian sumatif berbasis narasi dapat menjadi pendekatan yang tepat bagi pendidik untuk mengidentifikasi dan menganalisis kebutuhan spesifik siswanya. Implikasi dari penelitian ini adalah pentingnya mempertimbangkan faktor psikologis dan emosional siswa dalam merancang strategi pembelajaran matematika yang efektif.

ABSTRACT

Conventional mathematics teaching methods emphasize speed and accuracy, creating unnecessary pressure and often inaccurately measuring children's achievements. This research aims to build a framework, systematically examine students' affective areas, especially mathematical dispositions, and analyze the urgency of Advanced Mathematical Thinking (AMT). This research is a comprehensive investigative or exploratory mixed methods research using data triangulation. The subjects involved in this research were 80 elementary school students. The data collection method used was a questionnaire. In addition, this study combined open-ended questions and random narratives that captured participants' perspectives on mathematics learning. The data analysis technique uses qualitative and quantitative descriptive analysis. The research results show that teachers must consider students' various cognitive, emotional and psychomotor capacities and constraints during the educational process. This can be done using appropriate learning activities and methodologies, such as individual assignments and exploratory learning that adapt to students' abilities. Additionally, using narrative-based summative assessments can be an appropriate approach for educators to identify and analyze the specific needs of their students. This research implies the importance of considering students' psychological and emotional factors in designing effective mathematics learning strategies.

1. INTRODUCTION

Mathematics is the core discipline that underlies every branch of science and is an anchor for studying and comprehending patterns in the natural world. Mathematics is the crucial basis of education, including all scientific disciplines (Astalini et al., 2022; Sumantri & Satriani, 2016). Mathematics is also of utmost importance for children as it is directly applicable to their daily lives, aids in their cognitive growth, fosters the development of problem-solving abilities, which is an integral aspect of their cultural legacy, and serves as a predictor of their future academic achievements (Merrick & Fyfe, 2023; Novita et al., 2023; Shtulman & Young, 2023). It aids in developing crucial life skills, fosters understanding of the surrounding world, and contributes to personal, cultural, and societal growth. Mathematics provides the groundwork for understanding the patterns and phenomena of the universe around us as the foundational field that incorporates all branches of science and includes the crucial skill of teaching (Ernest, 2015;

*Corresponding author.
E-mail addresses: nadyadewindaa@gmail.com (Nadya Dewinda Agustin)

Guzmán et al., 2023). It has profound significance in all aspects of education. The standard process of learning mathematics involves optimizing five key aspects: representation, connection, communication, proof and reasoning, and problem-solving. According to these criteria, the goal of studying mathematics is for pupils to develop Advanced Mathematical Thinking (AMT). An AMT skill refers to one's capacity to analyze numerical information using logical reasoning, structured thinking, and pattern analysis (Tall, 1994, 1995, 1997, 2002). This skill is deductive and dynamic, and it is developed through a cognitive approach that stimulates students in mathematical representation, mathematical abstraction, mathematical creativity, and mathematical proofing. Prior studies included administering questions that assessed indications of AMT, such as mathematical thinking skills, mathematical representation, mathematical abstraction, and mathematical proofing (Agustin et al., 2024).

The persistence of conventional methods and standards that prioritize rapidity, effectiveness, and Accuracy places undue pressure on mathematics classrooms and inaccurately measures children's achievement in acquiring more mathematical knowledge. Traditional techniques often discourage the acceptance of bewilderment, constructive struggle, and blunders, portraying them as undesirable (Chiu et al., 2020; Weinberg et al., 2022). Teachers seldom encourage students to reflect on these instances and see them as typical elements of the learning process. Besides that, the cognitive capacities of pupils are also impacted by their emotional aptitudes. One factor that impacts pupils' learning is their inclination to resist and oppose mathematics (Ernest, 2015; Ibrahim et al., 2024). This inclination is referred to as a mathematical disposition. The fundamental variations in early learning development include a cheerful disposition, proficient numerical activity, and mathematical anxiety among students, teachers, and parents. Preconceived notions, convictions, and viewpoints on mathematics that exclusively target sure pupils might detrimentally affect their performance in the subject (Cheung et al., 2023; Guzmán et al., 2023; Jenifer et al., 2024; Maher et al., 2023; Metallidou & Vlachou, 2010). An investigation was conducted to examine the potential changes in the link between mathematics performance and three fundamental cognitive capacities (inhibition, working memory, and reasoning) throughout elementary school (Hilbert et al., 2019; Jenifer et al., 2024; Maher et al., 2023; Randler et al., 2005). This research provides indirect support for the study above as it highlights the adverse impact of mathematical anxiety on elementary school pupils. Mathematical anxiety may impede the functioning of the brain's working memory, creating a self-perpetuating loop characterized by avoiding arithmetic, poor academic performance, and dread (Li et al., 2023; Robson et al., 2023). The differentiation among these abilities in elementary school was first suggested as a potential reason for this trend, but it was ultimately dismissed after analyzing structural equation models (Barrenechea, 2022; Supramono & Retnawati, 2023). Therefore, when it comes to curricula that focus on producing results, academic benchmarks, and a wide range of individual differences among students, it is necessary for teachers to consider their students' various cognitive abilities and limitations (Hilbert et al., 2019). This can be achieved using appropriate tasks and teaching strategies such as self-differentiating tasks and adaptive explorative learning. Teachers must consider not just the cognitive ability of their students but also their emotional and psychomotor capabilities, both at the class level and, due to the diversity of children in primary schools, at the individual level (Affandi et al., 2020; Bueno & Niess, 2023; Li et al., 2023; McMain, n.d.; Rahman & Aminah, 2022). Elementary teachers must understand the specific viewpoints and emotions associated with various arithmetic assignments to effectively adjust their teaching tactics (Blazar & Pollard, 2023; Liverani et al., 2023). Hence, there is a need to enhance the calibre of mathematics education. One way to begin this process is by investigating students' cognitive and affective experiences when they are engaged in mathematics learning (Hunt et al., 2023; Nopitasari et al., 2023). This analysis is about the impact on students in terms of their concentration, confusion, problem-solving skills, and knowledge acquisition. Additionally, it explores potential recommendations to enhance the effectiveness of mathematics education in elementary schools. Therefore, this study aims to build a framework to systematically examine students' affective areas, especially mathematical disposition, to analyze the urgency of Advanced Mathematical Thinking (AMT). The implication of this study is the importance of paying attention to students' psychological and emotional factors in designing effective mathematics learning strategies.

2. METHODS

This study is a comprehensive investigation or exploratory mixed-methods study using data triangulation. It focuses on analyzing 80 transcripts obtained from a summative assessment conducted in a questionnaire using Quizziz. The questionnaire was constructed using a Likert scale to answer n-ended questions, a prevalent measuring scale used in surveys, and a space to express their feelings and perspectives through stories. The answer choices included 4 for highly agree, 3 for agree, 2 for disagree, and 1 for severely disagree. The perception instrument outcomes are categorized using the following ranges: Very High (VH: 3.26 -4), High (H: 2.51 – 3.25), Low (L: 1.76 – 2.5), and Very Low (VL: 1 - 1.75). More importantly, the criteria for the optimum evaluation are classified based on their subsequent intervals: Recommend ($\bar{X} > M_i + 1.8SBi$), Acceptable ($M_i + 0.6SB_i < \bar{X} \leq M_i + 1.8SBi$) , Good ($M_i - 0.6SB_i < \bar{X} \leq M_i + 0.6SBi$), Enough ($M_i - 1.8SB_i < \bar{X} \leq M_i - 0.6SBi$), Bad ($\bar{X} \leq M_i - 1.8SBi$), with M_i is ideal mean, SBi is ideal standard deviation, $\bar{X}$ is mean of the total.

The embedded strategy in this study is a nested approach used when quantitative or qualitative data is of the utmost importance to the researcher. This strategy is used when distinct inquiries need diverse forms of data, including both qualitative and quantitative. This research analyses students' responses by examining their perspectives and narratives. Neither an intervention nor an experiment, this research aimed not to explain the phenomena but to comprehend the themes that arose from the narratives and perceptions guided by the implications of the quantitative data. For a more comprehensive understanding of this work. A comprehensive quantitative analysis of the entire corpus using Excel for descriptive analysis, Colabs for topic modelling using Latent Dirichlet Allocation (LDA), and a sentiment analysis approach using the VADER method with the NLTK library. Pandas were used in the pre-processing and post-processing stages of LDA workflows. These two quantitative analytic approaches aided the study team in achieving two objectives: 1) automating the identification of ideas on a large scale to locate pertinent remarks for qualitative analysis and 2) providing contextualization for sentiment ratings inside the transcripts. The scope of sentiment analysis is restricted since the model needs more training to determine the student's intentionality or positionality (Kalinec-Craig & Rios, 2024). The sentiment analysis facilitated our comprehension of the tone and emotions expressed in the text. However, a qualitative researcher with knowledge of the subject matter and descriptions might fulfil this task if prompted by the study question. The topic modelling procedure enabled us to methodically train the algorithm to characterize groups of words, particularly those critical in our research (Asmussen & Møller, 2019; Yu et al., 2023). After completing the quantitative analysis, the study examined the subjects and identified words related to students' emotions to capture the fundamental aspects of human experiences. These words can also be organized and presented in hierarchical outline formats as an analytical strategy. The items excluded and included for theme analysis are presented in Table 1.

Table 1. Text Included and Excluded for Qualitative: Thematic Analysis

Included	Excluded
I like it, but I need to be more confident in getting it right. I like it but find it difficult and need to memorize it. Math is challenging.	Firstly, I couldn't do division and multiplication, so my dad taught me that I could do them until now.
I need help understanding math.	I cheat sometimes.
Math makes me moody and dizzy.	I like learning math that has formulas.
I like learning math because it is easy once we understand it.	I prefer doing something other than math with story problems.
I am happy because I can understand quickly. When I study math, I enjoy it because I find the problems easy and exciting, but I would not say I like it the most when my peers cheat.	Based on my capability to answer, I feel happy because the maths questions are easy, while I feel unhappy because the questions are difficult
. I would not say I like maths. Math problems are confusing; it makes me very dizzy. I prefer to avoid learning maths.	An aspect that I find displeasing when studying mathematics is the interruption caused by my friends for casual conversations. Conversely, I get satisfaction from achieving a perfect score by successfully solving mathematical questions.
Math is both fun and challenging at times.	Be active in learning Math!

Descriptive analysis encompasses many tests that assess the internal consistency of data, including validity and reliability. Cronbach's alpha is a statistical metric used to evaluate the degree of internal consistency within a group, indicating the extent to which its members are strongly interconnected as a unified entity (Hill & Seah, 2023; Hsu et al., 2019; Huntington et al., 2023). This questionnaire's results' internal consistency and dependability are deemed suitable, with a reliability coefficient of 0.73 (see Table 2). A score nearing 1 indicates higher reliability (Loeb et al., 2017). The data obtained from this questionnaire is valid, supported by the explanatory information provided. Question 5 displayed the most significant level, while question 15 showcased the lowest level. However, the frequency count of questions 1 through 15 exceeds 0.2139. Based on this, every question is valid. The participants of this exploratory study included 80 fifth-grade elementary school pupils, which accounted for the majority of the entire population of 85 pupils, considering the absence of specific students. When selecting a sample, it is essential to consider the size and attributes of the population, as well as the acceptable range of error. Utilizing a sample size determination formula is a very effective method for selecting a representative sample from a heterogeneous population. Table 1 displays the calculation of samples, with 68 and 70 being determined using the Issac and Michael method and the Krejcie and Morgan formula, respectively presented in Table 2. Hence, the sample sizes were deemed to be statistically robust (Isaac & Michael, 1987; Krejcie & Morgan, 1970).

Table 2. Internal Consistency of The Data Source

No	Indicator	Value
1	Number of Items	15
2	Realization Number of Sample	80
3	Number of Population	85
4	Sample size calculation based on Issac and Michael's method with a significance level (α) of 0.05	68
5	Sample size calculation based on Krejcie and Morgan's method with a significance level (α) of 0.05	70
6	Cronbach's Alpha Based on Standardized Items	0.73
7	The Accuracy of this rule-based sentiment analysis model	96%

The coherence score derived from CV topic modelling was used to assess the internal coherence of the topic in this qualitative study dataset. The coherence score for cv typically ranges from 0 to 1, with higher values indicating a higher degree of coherence, characterized by distinct and coherent topics within the data. A coherence score in topic modelling is a numerical measure utilized to assess the degree of semantic relatedness among the words inside a topic. Furthermore, scores beyond 0.4 are often considered acceptable. However, aiming for higher scores, ideally ranging from 0.6 to 0.7+, is recommended. Generally, the coherence score exhibited periodic variations. The coherence score exhibits a downward trend as the number of topics increases. Choosing the model that achieved the most excellent cross-validation score before reaching a plateau or experiencing a significant decline would be more prudent. For this particular instance, we selected a value of K equal to 7. However, the subject coherence score of the remaining topics tended to vary as the number of topics increased, reaching its highest at 17 topics and then decreasing dramatically. The rule-based sentiment analysis algorithm that's also used to assess the internal coherence of the topic achieves an impressive overall accuracy of 96% (see Table 2).

3. RESULT AND DISCUSSION

Results

This section describes the findings from studies that use both qualitative and quantitative research methods, either exploratory or thorough. The following part will give the results on topic modelling, sentiment analysis, and the themes from the qualitative study of primary school children's viewpoints and emotions regarding mathematics in the transcripts. The following are the levels of each category in the questionnaire presented in Table 3.

Table 3. Descriptive AnalAnalysised on its Criteria

Overall Questionnaires	Confidence	2.8925	High	14.4625	72%	Acceptable
42.1	Enthusiasm	3.1281	High	12.5125	78%	Acceptable
70%	Curiosity	2.3469	High	12.5125	78%	Acceptable
Acceptable	Satisfaction	2.8688	High	5.7375	72%	Acceptable

Table 3 demonstrates that every component of the student's evaluation of learning is at a high level, except for the need to improve learning techniques and tactics, which is now at an acceptable level. A study conducted on 258 grade 3 primary school students revealed that students appreciated all learning experiences to varying degrees. Among the factors that made them feel better receiving high results, engaging in enjoyable and exciting activities, watching math-related films, and receiving praise from their teacher were most often mentioned. The results also emphasize the cultural subjectivity at play, whereby identical classroom activities might manifest distinct underlying values across cultures, and wherever a specific value can be adopted in diverse manners in various locations. Furthermore, the incentives for accomplishment and involvement were very noticeable to us first. In conclusion, their satisfaction in studying mathematics stemmed from their capacity to achieve and embody a genuine understanding of pleasant emotions and, perhaps, a feeling of purpose. Regarding confidence (Q1-Q5), although 56% of the children concurred that mathematics is challenging, a minimum of 77% acknowledged that mathematics is challenging. Additionally, it was observed that at least 58% of the students feel sad when they cannot solve mathematical problems, and 60% agreed that mathematicians often experience perplexity and intimidation. However, despite these findings, a minimum of 93% of the students still agreed that achieving high scores in mathematics brings them happiness. In addition, the overall data on children's curiosity (Q6-Q9) indicates that their motivation levels are very high. Specifically, 95% of children desire to excel in mathematics, 98% are driven to get excellent grades, 86% exhibit great competition, and 77% display enthusiasm towards studying mathematics.

Child participation exhibited the lowest level among the other components (Q10-Q13) while maintaining a commendable and satisfactory level. Merely 45% of pupils derived pleasure from comprehending mathematics via videos and interactive activities. A significant majority of students, 68%, reported being able to sustain attention and concentration, while 64% claimed to have effectively optimized their focus throughout the learning process. Nevertheless, 49% of the student population acknowledged their susceptibility to distraction. Regarding students' enthusiasm for studying mathematics (Q14-Q15), it is noteworthy that a significant proportion of students, 79%, tend to rely on memorization rather than comprehension when dealing with mathematical ideas and processes. Additionally, 59% of students have challenges maintaining attention and concentration. Based on the sentiment analysis findings in Figure 6, the consensus among students is that their attitudes and feelings towards mathematics are mostly unfavourable. This is shown by using topic modelling and the LDA model. The predominant emotion associated with issue 0 is challenging, topic 1 is delighted, topic 2 is unpleasant, topic 3 is challenging, and topic 4 is complex. From topic 0 to topic 4, it can be seen that the topics are dominated by negative topics such as cheating, sour, bored, faint, unpleasant, worried, misunderstood, confusing, exhausted, tough, terrified, and complex. There was a favourable correlation between students' belief in their ability to do well in mathematics and their ability to adapt to elementary school. Students exhibiting elevated levels of mathematics disposition tended to express favourable attitudes towards school, establish improved rapport with educators and classmates, and encounter fewer behavioural issues. Figure 1 displays each subject's Davis and Wordcloud representations ranging from 0 to 4 in the LDA model. Each topic, labelled as 1, 2, 3, 4, and 5, is represented by a word cloud corresponding to topics 0, 1, 2, 3, and 4, respectively. Here is Davis in Topic Modeling using LDA and its word cloud presented in Figure 1.

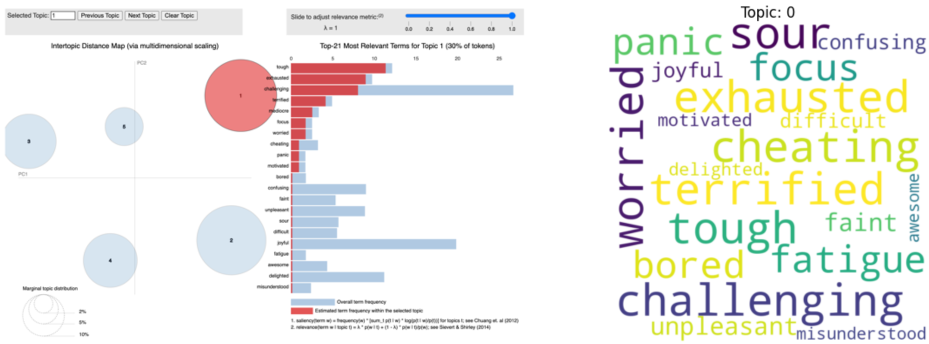

Figure 1. Davis in Topic Modeling Using LDA and Its Word Cloud

Discussion

A study conducted on 258 grade 3 primary school students revealed that students appreciated all learning experiences to varying degrees (Hill & Seah, 2023). Among the factors that made them feel better receiving high results, engaging in enjoyable and exciting activities, watching math-related films, and receiving praise from their teacher were most often mentioned (Burgos et al., 2020; Demir & Birgili, 2023; Kersey et al., 2018; Naidoo & Hajaree, 2021; Pitchford et al., 2019; Zhao et al., 2022). The results also emphasize the cultural subjectivity at play, whereby identical classroom activities might manifest distinct underlying values across cultures, and wherever a specific value can be adopted in diverse manners in various locations (Holenko Dlab et al., 2020; Langer-Osuna et al., 2021; Layne et al., 2021; Nurhidayah et al., 2021; Palmér & Björklund, 2023). Students exhibiting elevated levels of mathematics anxiety had a greater propensity for encountering difficulties in peer interactions, classroom conduct, and academic achievement. Another study also discovered that proficiency in mathematics at an early stage is the most reliable indicator of successful adaptation to the educational environment (Siegler et al., 2012). Students with more advanced early mathematical abilities were likelier to express good attitudes towards school, cultivate better connections with instructors and classmates, and encounter fewer behavioural issues. This research combines qualitative and quantitative approaches that provide in-depth insight into elementary school students' viewpoints and emotions toward mathematics. Using analytical methods such as topic modeling and sentiment analysis adds complexity and depth to the analysis, providing a more comprehensive understanding of students' experiences. The findings also highlight factors that can increase students' satisfaction with learning mathematics, such as teacher praise and engagement in fun activities. However, this study has limitations, especially in the generalizability of the results due to the focus on one primary school level and the use of questionnaires to measure students' perceptions, which may introduce interpretation errors. The solution to this limitation is to expand the sample coverage and validate the instrument used. Future research can refer to previous studies that highlight the relationship between math anxiety, self-efficacy, and student adaptation in the primary school setting to deepen the understanding of the factors that influence students' attitudes and performance in mathematics.The implication of this study is the importance of paying attention to students' psychological and emotional factors in designing effective mathematics learning strategies. Teachers and educational policymakers can use these findings to increase students' motivation and participation in mathematics learning by providing more rewards and recognition for students' achievements. In addition, these findings can serve as a basis for further research in educational psychology to understand more deeply the relationship between emotions, attitudes, and performance in mathematics learning.

4. CONCLUSION

Our study advocates further research on topic modelling and sentiment analysis in capturing terms such as "unpleasant, challenging, and scary," especially in the context of student and teacher responses. Students often face difficulties coping with uncertainty, complexity and errors in math class. However, teachers have the potential to view confusion, constructive struggle and mistakes as a natural part of learning. This research suggests that teachers should avoid giving false praise and instead view confusion and errors as opportunities to develop students' independent learning skills. Teachers must also recognize students' struggles and distinguish between productive and unproductive struggles. Nonetheless, our study recognizes limitations and highlights the importance of future research to articulate student challenges more empathetically.

5. REFERENCES

Affandi, L. H., Saputra, H. H., & Husniati, H. (2020). Teaching for What? - Investigating the Effect of Teacher's Pedagogical Knowledge on Elementary School Students' Life Satisfaction and Outcome. *Universal Journal of Educational Research*, *8*(11), 5367–5375. https://doi.org/10.13189/UJER.2020.081139.

Agustin, N. D., Usman, H., & Sumantri, M. S. (2024). Elementary School Mathematics Education: Are Students Enthusiastic About Learning Mathematics? Students' And Teacher Perspectives. *The Seybold Report*, *19*(1), 30–46. https://seyboldreport.org/article_overview?id=MDEyMDI0MDYwMzQ0NDU0MzIy.

Asmussen, C. B., & Møller, C. (2019). Smart literature review: a practical topic modelling approach to exploratory literature review. *Journal of Big Data*, *6*(1), 1–18. https://doi.org/10.1186/S40537-019-0255-7/TABLES/6.

Astalini, D., Kurniawan, D. A., Chen, D., Fitriani, R., Wulandari, M., Maryani, S., Simamora, N. N., & Ramadhanti, A. (2022). A Study for Student Perception of Mathematical Physics E-Module Based on Gender. *Journal of Turkish Science Education*, *19*(3), 911. https://doi.org/10.36681/tused.2022.156.

Blazar, D., & Pollard, C. (2023). Challenges and Tradeoffs of "Good" Teaching: The Pursuit of Multiple Educational Outcomes. *Journal of Teacher Education*, *74*(3), 229–244. https://doi.org/10.1177/00224871231155830/SUPPL_FILE/SJ-DOCX-1-JTE-10.1177_00224871231155830.DOCX.

Bueno, R. W. d. S., & Niess, M. L. (2023). Redesigning mathematics preservice teachers' preparation for teaching with technology: A qualitative cross-case analysis using TPACK lenses. *Computers & Education*, *205*, 104895. https://doi.org/10.1016/J.COMPEDU.2023.104895.

Burgos, M., Beltrán-Pellicer, P., & Godino, J. D. (2020). The issue of didactical suitability in mathematics educational videos: Experience analyzing prospective primary school teachers. *Revista Espanola de Pedagogia*, *78*(275), 27–49. https://doi.org/10.22550/REP78-1-2020-07.

Cates, G. L., & Rhymer, K. N. (2003). Examining the Relationship Between Mathematics Anxiety and Mathematics Performance: An Instructional Hierarchy Perspective on JSTOR. *Journal of Behavioral Education*, *12*(1), 23–34. https://www.jstor.org/stable/41824291.

Cheung, S. K., Kwan, J. L. Y., Li, Z. Y., Chan, Y. Y., & Kwan, K. T. (2023). Parents' epistemological beliefs to children's early numeracy abilities: Pathways through parents' home practices and children's numeracy interest. *Early Childhood Research Quarterly*, *65*, 13–22. https://doi.org/https://doi.org/10.1016/j.ecresq.2023.05.005.

Chiu, T. K. F., Jong, M. S. yun., & Mok, I. A. C. (2020). Does learner expertise matter when designing emotional multimedia for learners of primary school mathematics? *Educational Technology Research and Development*, *68*(5), 2305–2320. https://doi.org/10.1007/S11423-020-09775-4/TABLES/2.

Demir, Ö., & Birgili, B. (2023). The mediating role of instructional design and video length between grade level and pupil-content interaction in instructional mathematics videos on YouTube. *Education and Information Technologies*, *1–31*(2024). https://doi.org/https://doi.org/10.1007/s10639-023-12004-z.

Ernest, P. (2015). The Social Outcomes of Learning Mathematics: Standard, Unintended or Visionary? *International Journal of Education in Mathematics*, *3*(3), 187–192. https://www.ijemst.net/index.php/ijemst/article/view/62.

Guzmán, B., Rodríguez, C., & Ferreira, R. A. (2023). Effect of parents' mathematics anxiety and home numeracy activities on young children's math performance-anxiety relationship. *Contemporary Educational Psychology*, *72*, 102140. https://doi.org/https://doi.org/10.1016/j.cedpsych.2022.102140.

Hilbert, S., Bruckmaier, G., Binder, K., Krauss, S., & Bühner, M. (2019). Prediction of elementary mathematics grades by cognitive abilities. *European Journal of Psychology of Education*, *34*(3), 665–683. https://doi.org/https://doi.org/10.1007/s10212-018-0394-9.

Hill, J. L., & Seah, W. T. (2023). Student values and wellbeing in mathematics education: perspectives of Chinese primary students. *ZDM - Mathematics Education*, *55*(2), 385–398. https://doi.org/https://doi.org/10.1007/s11858-022-01418-7.

Holenko Dlab, M., Boticki, I., Hoic-Bozic, N., & Looi, C. K. (2020). Exploring group interactions in synchronous mobile computer-supported learning activities. *Computers & Education*, *146*, 103735. https://doi.org/https://doi.org/10.1016/j.compedu.2019.103735.

Hsu, H. P., Wenting, Z., & Hughes, J. E. (2019). Developing Elementary Students' Digital Literacy Through Augmented Reality Creation: Insights From a Longitudinal Analysis of Questionnaires, Interviews, and Projects. *Journal of Educational Computing Research*, *57*(6), 1400–1435. https://doi.org/https://doi.org/10.1177/0735633118794515.

Hunt, J., Taub, M., Duarte, A., Bentley, B., Womack-Adams, K., Marino, M., Holman, K., & Kuhlman, A. (2023). Elementary Teachers' Perceptions and Enactment of Supplemental, Game-Enhanced Fraction Intervention. *Education Sciences*, *13*(11), 1071. https://doi.org/http://dx.doi.org/10.3390/educsci13111071.

Huntington, B., Goulding, J., & Pitchford, N. J. (2023). Expert perspectives on how educational technology may support autonomous learning for remote out-of-school children in low-income contexts. *International Journal of Educational Research Open*, 5,100263. https://doi.org/https://doi.org/10.1016/j.ijedro.2023.100263.

Ibrahim, K., A., I., & Indra Prahmana, R. C. (2024). Mathematics learning orientation: Mathematical creative thinking ability or creative disposition? *Journal on Mathematics Education*, *15*(1), 253–276. https://doi.org/10.22342/jme.v15i1.pp253-276.

Isaac, S., & Michael, W. B. (1987). *Handbook in Research and Evaluation for Education and the Behavioral Sciences*. Edits Publisher.

Jenifer, J. B., Jaxon, J., Levine, S. C., & Cimpian, A. (2024). You need to be super smart to do well in math!" Young children's field-specific ability beliefs. *Developmental Science*, *27*(1), 13429. https://doi.org/10.1111/DESC.13429.

Kalinec-Craig, C., & Rios, A. (2024). Exploratory mixed methods study about teacher candidates' descriptions of children's confusion, productive struggle, and mistakes in an elementary mathematics methods course. *Journal of Mathematical Behavior*, 73,101103. https://doi.org/10.1016/j.jmathb.2023.101103.

Kersey, A. J., Braham, E. J., Csumitta, K. D., Libertus, M. E., & Cantlon, J. F. (2018). There are no intrinsic gender differences in children's earliest numerical abilities. *Npj Science of Learning*, *3*(1), 1–10. https://doi.org/10.1038/S41539-018-0028-7.

Krejcie, R. V, & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, *30*. https://doi.org/10.1177/001316447003000308.

Langer-Osuna, J. M., Chavez, R., Kwon, F., Malamut, J., Gargroetzi, E., Lange, K., & Ramirez, J. (2021). I'm Telling!": Exploring Sources of Peer Authority During a K-2 Collaborative Mathematics Activity. *Studia Paedagogica*, *26*(2), 97–111. https://doi.org/10.5817/SP2021-2-5.

Layne, T., Yli-Piipari, S., & Knox, T. (2021). Physical activity break program to improve elementary students' executive function and mathematics performance. *Education*, *49*(5), 583–591. https://doi.org/10.1080/03004279.2020.1746820.

Li, H., Zhang, M., Hou, S., Huang, B., Xu, C., Li, Z., & Si, J. (2023). Examining the dynamic links among perceived teacher support, mathematics learning engagement, and dimensions of mathematics anxiety in elementary school students: A Four-wave longitudinal study. *Contemporary Educational Psychology*, *75*, 102211. https://doi.org/10.1016/J.cedpsych.2023.102211.

Liverani, M. C., Kalogirou, E., Rivier, C., & Gentaz, E. (2023). Effects of two types of numerical problems on the emotions experienced in adults and in 9-year-old children. *PLOS ONE*, *18*(11), 289027. https://doi.org/10.1371/journal.pone.0289027.

Loeb, S., Dynarski, S., Mcfarland, D., Morris, P., Reardon, S., & Reber, S. (2017). *Descriptive Analysiseducation: A guide for researchers The National Center for Education Evaluation and Regional Assistance (NCEE) conducts unbiased large-scale evaluations of education programs and practices*. http://ies.ed.gov/ncee/.

Maher, C. A., Maher, J. A., Palius, M. F., & Wilkinson, L. C. (2023). Teachers attending to student reasoning: Do beliefs matter? *The Journal of Mathematical Behavior*, *69*, 101050. https://doi.org/10.1016/j.jmathb.2023.101050.

McMain, E. M. (n.d.). *Drawing the line: Teachers affectively and discursively question what counts as "appropriate behavior*. https://doi.org/10.1177/17577438231200344.

Merrick, M., & Fyfe, E. R. (2023). Feelings on feedback: Children's emotional responses during mathematics problem solving. *Contemporary Educational Psychology*, *74*, 102209. https://doi.org/10.1016/J.cedpsych.2023.102209.

Metallidou, P., & Vlachou, A. (2010). Children's self-regulated learning profile in language and mathematics: The role of task value beliefs. *Psychology in the Schools*, *47*(8), 776–788. https://doi.org/10.1002/pits.20503.

Naidoo, J., & Hajaree, S. (2021). Exploring the perceptions of Grade 5 learners about the use of videos and PowerPoint presentations when learning fractions in mathematics. *South African Journal of Childhood Education*, *11*(1), 12. https://doi.org/10.4102/SAJCE.V11I1.846.

Nopitasari, A., S., B., Riyanto, S., & Murti, R. C. (2023). Digital Literacy: Perceptions of Primary School Teacher Education Students. *Jurnal Ilmiah Sekolah Dasar*, *7*(1), 27–34. https://doi.org/10.23887/JISD.V7I1.48400.

Novita, S., Schönmoser, C., & Lipowska, M. (2023). Parent and teacher judgments about children's mathematics and reading competencies in primary school: Do parent judgments associate with children's educational outcomes? *Learning and Individual Differences*, *105*, 102302. https://doi.org/10.1016/J.LINDIF.2023.102302.

Nurhidayah, I. J., Wibowo, F. C., & Astra, I. M. (2021). Project Based Learning (PjBL) learning model in science learning: Literature review. *Journal of Physics: Conference Series*, *2019*(1). https://doi.org/10.1088/1742-6596/2019/1/012043.

Palmér, H., & Björklund, C. (2023). The Teaching of Numbers in Common Preschool Activities: A Delicate Balancing Act. *Early Childhood Education Journal*, *51*, 971–980. https://doi.org/10.1007/s10643-022-01354-x.

Pitchford, N. J., Chigeda, A., & Hubber, P. J. (2019). Interactive apps prevent gender discrepancies in early-grade mathematics in a low-income country in sub-Sahara Africa. *Developmental Science*, *22*(5), 12864. https://doi.org/10.1111/desc.12864.

Rahman, M. A., & Aminah, A. A. (2022). Murrderr Strategy: Developing Creative Characters of Elementary School Prospective Teachers. *International Journal of Instruction*, *15*(1), 547–564. https://doi.org/10.29333/iji.2022.15131a.

Randler, C., Ilg, A., & Kern, J. (2005). Cognitive and Emotional Evaluation of an Amphibian Conservation Program for Elementary School Students. *The Journal of Environmental Education*, *37*(1), 43–52. https://doi.org/10.3200/joee.37.1.43-52.

Robson, D. A., Johnstone, S. J., Putwain, D. W., & Howard, S. (2023). Test anxiety in primary school children: A 20-year systematic review and meta-analysis. *Journal of School Psychology*, *98*, 39–60. https://doi.org/10.1016/j.jsp.2023.02.003.

Setiawan, A. (2023). An exploratory sequential mixed-methods approach to understanding students' entrepreneurial self-efficacy. *Journal of Turkish Science Education*, *20*(2), 320–332. https://doi.org/10.36681/TUSED.2023.018.

Shtulman, A., & Young, A. G. (2023). The development of cognitive reflection. *Child Development Perspectives*, *17*(1), 59–66. https://doi.org/10.1111/cdep.12476.

Siegler, R. S., Duncan, G. J., Davis-Kean, P. E., Duckworth, K., Claessens, A., Engel, M., Susperreguy, M. I., & Chen, M. (2012). Early Predictors of High School Mathematics Achievement. *Psychological Science*, *23*(7), 691–697. https://doi.org/http://dx.doi.org/10.1177/0956797612440101.

Sumantri, M. S., & Satriani, R. (2016). The Effect of Formative Testing and Self-Directed Learning on Mathematics Learning Outcomes. *International Electronic Journal of Elementary Education*, *8*(3), 507–524. www.simdik.info/hasilun/index.aspx.

Tall, D. (1994). The Psychology of Advanced Mathematical Thinking. *Biological Brain and Mathematical Mind*, *3*(21), XVIII, 292. https://doi.org/http://dx.doi.org/10.1007/0-306-47203-1_1.

Tall, D. (1995). Cognitive Growth in Elementary and Advanced Mathematical Thinking. *L'Enseignement Mathématique*, *1*, 161–175. https://doi.org/https://www.researchgate.net/publication/248206605.

Tall, D. (1997). From School to University: the Transition from Elementary to Advanced Mathematical Thinking. *Australasian Bridging Conference in Mathematics at Auckland University*. https://doi.org/http://dx.doi.org/10.1007/s10763-016-9744-8.

Tall, D. (2002). The Psychology of Advanced Mathematical Thinking. In *Advanced Mathematical Thinking* (pp. 3–21). https://doi.org/10.1007/0-306-47203-1_1.

Weinberg, A., Wiesner, E., & Fitts Fulmer, E. (2022). Didactical Disciplinary Literacy in Mathematics: Making Meaning From Textbooks. *International Journal of Research in Undergraduate Mathematics Education*, *9*, 491–523. https://doi.org/10.1007/s40753-022-00164-1.

Yu, D., Fang, A., & Xu, Z. (2023). Topic research in fuzzy domain: Based on LDA topic modelling. *Information Sciences*, *648*, 119600. https://doi.org/10.1016/j.ins.2023.119600.

Zhao, Q., Wininger, S., & Hendricks, J. (2022). The interactive effects of gender and implicit theories of abilities on mathematics and science achievements. *Australian Educational Researcher*, *49*(1), 115–133. https://doi.org/10.1007/S13384-021-00430-2/FIGURES/2.