Online-Journals.org

iJIM International Journal of Interactive Mobile Technologies

iJIM | eISSN: 1865-7923 | Vol. 20 No. 11 (2026) | OPEN ACCESS

https://doi.org/10.3991/ijim.v20i11.61541

PAPER

Interactive Artificial Intelligence Assistants for Reducing Mathematics Anxiety in Primary Teacher Education

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ABSTRACT

Mathematics anxiety represents a significant affective barrier in learning mathematics and may influence both students' academic performance and their future teaching practice. In teacher education, its reduction is particularly important because negative attitudes toward mathematics may later be transferred to pupils. This study examines the relationship between the perceived pedagogical value (PPV) of an artificial intelligence (AI) assistant and the perceived reduction of mathematics anxiety and explores the mechanism through which AI-supported learning influences students' affective experience. The study was conducted among students in a primary teacher education program within a course focused on the didactics of arithmetic. Two forms of AI support were implemented: an interactive AI assistant, the Didactic-Arithmetic Coach (DAK), and AI-generated thematic podcasts. Data were analyzed using exploratory factor analysis, correlation, regression, and mediation analysis. The results indicate that the perceived reduction of mathematics anxiety is strongly associated with the academic support provided by the AI assistant, with situational stress reduction acting as a mediating mechanism.

KEYWORDS

mathematics anxiety, artificial intelligence (AI) in education, teacher education, self-efficacy, AI assistants

1 INTRODUCTION

Mathematics anxiety represents a significant affective factor influencing the learning of mathematics across all levels of education [1], [2]. It is a complex construct associated with decreased performance, avoidance behavior, and increased cognitive load during the solving of mathematical problems [3], [4].

In the preparation of future teachers, mathematics anxiety has particular significance because it can be transmitted to pupils and influence their attitudes toward mathematics [5]. At the same time, it is associated with lower pedagogical self-confidence and a reduced willingness to work with more demanding tasks [6], [7]. Motivational factors, values, and attitudes constitute an important component of the

Babicová, D., Jablonský, T., Tkačik, Š., Tkačik, Š., Jr. (2026). Interactive Artificial Intelligence Assistants for Reducing Mathematics Anxiety in Primary Teacher Education. *International Journal of Interactive Mobile Technologies (iJIM)*, 20(11), pp. 103–125. https://doi.org/10.3991/ijim.v20i11.61541

Article submitted 2026-03-14. Revision uploaded 2026-04-20. Final acceptance 2026-04-27.

professional profile of future teachers and co-shape their pedagogical decision-making and their relationship to the curriculum, as well as the emotional experience of professional situations [8]. Therefore, reducing mathematics anxiety in teacher education is crucial not only from the perspective of individual learning but also from the perspective of the quality of future mathematics instruction.

In recent years, digital technologies, including artificial intelligence (AI), have begun to be integrated into this context, enabling the provision of individualized learning support. AI-supported tools can create an environment with lower evaluative pressure, provide immediate feedback, and allow repeated attempts at solutions, which are factors that may contribute to the reduction of anxiety during learning [9]. At the same time, it has been shown that the perception of control and competence supported by adaptive technologies plays an important role in the regulation of academic emotions [10].

These mechanisms are particularly relevant in teacher education, where learners differ substantially in their technological readiness and digital competence. As digital technologies shape their learning strategies and expectations, questionnaire-based assessment of preparedness, attitudes toward technological tools, and prior experience is an appropriate methodological approach [11], [12] when implementing AI-supported educational interventions.

Despite the growing interest in the use of AI in education, research on its impact on mathematics anxiety among future teachers remains limited. Studies examining the mechanisms through which technological support influences the emotional experience of teaching and learning mathematics in teacher education are still lacking.

The present study is the result of research focused on the integration of AI into the mathematical preparation of future primary education teachers. In a previous study conducted by the authors with the same population of students, key predictors of the adoption of AI in learning were identified, particularly openness toward AI, perceived AI skills, and attitudes toward podcasts as a learning tool [13].

Based on these empirical foundations, an intervention was designed within the course *Primary Mathematics Education—Arithmetic*, employing two author-developed forms of AI support: an interactive AI assistant—the Didactic-Arithmetic Coach (DAK)—and supplementary thematic podcasts generated using AI. This context makes it possible to examine whether technologically mediated learning support can contribute to the reduction of mathematics anxiety and what mechanisms mediate this process.

The aim of the study is to examine the relationship between the perceived pedagogical value (PPV) of AI tools and the reduction of mathematics anxiety, as well as to identify the mechanism through which AI-supported learning influences the emotional experience of learning mathematics.

2 THEORETICAL BACKGROUND AND CONCEPTUALIZATION OF THE EXAMINED CONSTRUCTS

2.1 Theoretical foundations of AI-supported design in the context of mathematics anxiety

Mathematics anxiety is defined as a set of negative emotional reactions, particularly tension, stress, and worry, that are activated when manipulating numbers or solving mathematical problems [14]. Research has long pointed to its negative impact on working memory, performance, and avoidance behavior [3], [4]. In the case of future primary education teachers, this phenomenon has increased significance because their own uncertainty may indirectly shape pupils' attitudes toward mathematics and influence their pedagogical decision-making [5].

Theoretical models of mathematics anxiety emphasize the importance of the perception of control over problem-solving, clarity of procedures, the possibility of working safely with errors, and the strengthening of self-confidence (more precisely, self-efficacy). The reduction of anxiety is therefore often associated with an increased sense of task mastery (mastery experience), which Bandura identifies as one of the key sources of self-efficacy [15].

The design of technological support in the present study is based on empirical findings from previous research conducted by the authors with the same population of students, which identified key factors influencing the adoption of artificial intelligence in the context of the mathematical preparation of future teachers. Openness toward AI, perceived AI skills, and attitudes toward podcasts as a learning support emerged as significant predictors [13]. At the same time, the results of that study indicated that the mere acceptance of technology is not sufficient for its pedagogical effectiveness; rather, the decisive role is played by the way in which the technology is didactically integrated, especially the extent to which it supports understanding of the subject matter, active student engagement, and the sense of mastering learning tasks. Similarly, Papadakis emphasizes that the pedagogical value of AI lies not primarily in the technology itself but in how it is integrated into instructional design and how it supports personalized learning and active student engagement [16], [17]. In a broader context of preparing future mathematics teachers, emerging evidence suggests that generative AI available through mobile devices can have real didactic potential, provided that it is thoughtfully integrated into university teaching and accompanied by critical reflection on its limitations [18].

Building on these insights, the need emerged to design technological support in a way that provides a clear structure for problem-solving, enables the gradual mastery of tasks, and at the same time reduces the stress associated with learning. This perspective is further supported by evidence showing that more intensive use of ChatGPT was associated with lower academic stress among university students, suggesting that AI can function in learning not only as a source of information but also as a supportive tool for coping with workload [19]. These implications became the direct basis for the design of the intervention implemented in the present study.

Within the course Primary Mathematics Education—Arithmetic, a specialized author-developed AI assistant—the DAK—was implemented. It was designed to guide students step by step through the process of solving problems using targeted hints and to provide only such a level of support that preserves their active cognitive engagement. In parallel, students were provided with thematic podcasts created using AI technologies. These podcasts had a supplementary role and were intended primarily to reinforce the subject matter, support students with an auditory learning style, and reduce stress associated with the course. The AI assistant was technically implemented as a Custom GPT, while the podcasts were generated from original materials in the NotebookLM environment. A more detailed description of the concept of these tools and their implementation in teacher education is presented in a previous article [20].

Since the concept of the DAK AI assistant is based on guiding students through problem-solving using step-by-step instructions, it is conceptually close to the principle of scaffolding, specifically sequential scaffolding. Scaffolding represents a form of learning support that allows students to solve tasks slightly above their current level of independent competence and gradually assume control over the solution process. In the scholarly literature, this approach is described as an effective means of supporting mathematical thinking, reflection, and student autonomy [22], [23], [24].

In the case of DAK, however, this does not represent a strictly methodological implementation of scaffolding but rather a conceptual alignment in the provision of targeted and gradually reduced hints as a form of purposeful learning support.

Technological support designed in this way creates an environment in which students gain experiences of task mastery, which has the potential to increase their self-efficacy while simultaneously strengthening their perception of control over the problem-solving process.

Self-efficacy refers to an individual's belief in their ability to successfully accomplish a specific task and plays an important role in the regulation of motivation, persistence, and emotional responses during the learning process [15], [25]. In the context of mathematics education, higher levels of self-efficacy are consistently associated with lower levels of mathematics anxiety, higher engagement, and a greater willingness to work with more demanding tasks [26], [27]. One of the most important sources of self-efficacy is the mastery experience, which arises in situations where a student perceives gradual progress and feels a sense of control over the solution process [15].

A supportive environment based on the gradual guidance of problem-solving may therefore contribute to the reduction of mathematics anxiety indirectly, through the strengthening of self-efficacy and the perception of competence. In the literature, this mechanism is described as an important link between cognitive learning support and students' emotional responses, as higher self-efficacy mitigates anticipatory stress and promotes adaptive problem-solving strategies [28].

In the context of technology-supported learning, the effect of AI tools can be explained through two complementary mechanisms. The cognitive mechanism lies in providing structured support for problem-solving, for example, through scaffolding, adaptive feedback, and the decomposition of tasks into smaller steps. The affective mechanism is related to the creation of a less evaluative environment that reduces the fear of making mistakes and allows repeated attempts at solutions without immediate evaluative pressure. This is also consistent with more recent findings from iJIM, according to which effective self-directed learning among future mathematics teachers is closely associated with positive perceptions of formative support and intrinsic motivation, while these factors can be further enhanced by AI tools and digital platforms [21].

In the present study, these mechanisms were operationalized through two forms of AI support—the interactive AI assistant DAK and AI-generated podcasts—while it is assumed that these forms may operate through different mechanisms in reducing mathematics anxiety.

The present study examines the extent to which the perceived reduction of mathematics anxiety is associated with the PPV of AI tools and whether this relationship differs depending on the type of support (interactive AI assistant vs. podcasts). The starting assumption is that the reduction of anxiety may not be primarily a consequence of technological innovation itself, but rather a consequence of an increased sense of mastery of the subject matter, clarity of explanations, and structured guidance in the problem-solving process.

The objectives of the research are:

1. to psychometrically validate an index of mathematics anxiety reduction in the context of AI-supported learning,
2. to examine whether the reduction of mathematics anxiety consists of distinct cognitive and affective dimensions,
3. to analyze the relationships between anxiety reduction and the perceived academic and didactic value of the AI assistant, and
4. to identify a potential mechanism through which AI-supported learning influences the affective aspects of learning mathematics.

The study thus contributes to the discussion of whether, and in what way, AI in teacher education can contribute not only to improving the understanding of mathematics but also to reducing the negative emotional barriers associated with learning it.

2.2 Construction and psychometric validation of constructs

The aim of this study was not only to measure students' attitudes and experiences but also to construct psychometrically validated indices representing stable and theoretically coherent constructs. This section therefore presents the procedure used for constructing the individual indices, their conceptual grounding, and the results of reliability and factor structure validation.

Reduction of mathematics anxiety due to AI (ANX_MATH_RED)

Conceptualization of the construct. The construct ANX_MATH_RED was developed to capture the degree of perceived reduction in mathematics anxiety in the context of using AI tools during the semester. Theoretically, it assumes that anxiety reduction may be mediated by two distinct yet potentially complementary mechanisms:

1. Cognitive mastery of the subject matter through interactive support (DAK)
2. Emotional stabilization and comfortable preparation (podcasts)

The first mechanism involves cognitive mastery of the subject matter through interactive support provided by the DAK, which offers step-by-step explanations, enables safe experimentation with solutions, and reduces the fear of making mistakes. The second mechanism involves emotional stabilization and comfortable preparation, represented by AI-generated podcasts, which allow students to review the subject matter in a less stressful environment and without immediate evaluative pressure.

The construct also included a global item reflecting the overall perceived impact of AI tools on mathematics-related stress, ensuring that a broader subjective evaluation was captured.

Operationalization. The ANX_MATH_RED index was operationalized through six items rated on a 5-point Likert scale (1 = not at all, 5 = strongly agree). Reduction of stress associated with the use of DAK was measured by the following items:

- 14_2 – reduction of stress related to mathematics,
- 14_3 – reduced fear of making mistakes when solving problems, and
- 14_12 – overall reduction of stress related to the arithmetic course during the semester.

Reduction of stress associated with podcasts was captured by the items:

- 15_2 – reduction of stress related to arithmetic, and
- 15_5 – reduced stress related to tests and examinations.

The global impact of AI was represented by the item:

- 16_9 – Mathematics was less stressful thanks to AI tools.

The index was calculated as the arithmetic mean of the respective items.

Internal consistency – reliability. The reliability of the global index reached Cronbach's $\alpha = 0.870$, indicating high internal consistency and item homogeneity. The corrected item–total correlations ranged from 0.507 to 0.733, with all items exceeding the recommended threshold of 0.30. This indicates that each item contributes substantially to the measurement of the common construct.

From a psychometric perspective, ANX_MATH_RED can therefore be considered a stable and reliable indicator of the perceived reduction of mathematics anxiety.

Factor analysis and validation of the latent structure of the construct. Although a high value of Cronbach's alpha indicates internal consistency among the items, it does not answer the question of whether all items measure a single homogeneous construct or whether multiple latent dimensions underlie them. For this reason, an exploratory factor analysis (EFA) was conducted to examine the internal structure of the construct representing the reduction of mathematics anxiety.

Factor analysis is used to identify latent (indirectly measurable) variables that explain the correlations among questionnaire items. In the context of this study, it was important to verify whether the reduction of mathematics anxiety represents the following:

- a single global phenomenon, or
- a multidimensional construct differentiated by the type of AI support.

For factor extraction, the Principal Axis Factoring (PAF) method was used. This method is suitable when latent psychological constructs are assumed and does not require strict normality of the data. Since a correlation between the dimensions of stress reduction could theoretically be expected (e.g., between the effects of DAK and podcasts), an oblique Oblimin rotation was applied, allowing correlations between factors.

Before factor extraction, the suitability of the data for factor analysis was assessed.

- The Kaiser–Meyer–Olkin (KMO) index reached a value of 0.780, indicating a good degree of interrelatedness among the items. Values above 0.70 are considered adequate for factor analysis.
- Bartlett's test of sphericity was statistically significant ($p < 0.001$), indicating that the correlation matrix differs significantly from an identity matrix and that sufficiently strong correlations exist among the items.

These results confirm that the items are not randomly independent and that it is appropriate to search for common latent factors.

The analysis identified two factors (refer to Table 1), which together explained 70.7% of the total variance in responses, representing a high proportion of explained variance in educational research. The first factor can be interpreted as stress reduction mediated by interactive AI support (ANX_DAK), while the second factor represents emotional stabilization through podcasts (ANX_POD).

Table 1. Factor structure

Factor	Construct	Items
Factor 1	Stress reduction through DAK (ANX_DAK)	14_2, 14_3, 14_12
Factor 2	Stress reduction through podcasts (ANX_POD)	15_2, 15_5

The global item 16_9 ("mathematics was less stressful thanks to AI tools") showed moderate loadings on both factors, which is substantively logical since it reflects the overall effect without distinguishing between specific forms of support.

Significance of factor analysis for the interpretation of results. The implementation of factor analysis was crucial for three reasons:

1. Verification of construct validity—it confirmed that the items cluster according to the theoretically assumed mechanisms (interactive vs. podcast-based support).
2. Identification of subscales—it enabled the creation of two separate dimensions (ANX_DAK and ANX_POD), which can be analyzed independently.
3. Theoretical differentiation of AI impact mechanisms—it demonstrated that the reduction of anxiety is not a single "technological effect," but rather consists of both cognitive and affective components (refer to Table 2).

Table 2. Reliability of the stress reduction subscales

Index	Items	Cronbach's α
ANX_DAK	14_2, 14_3, 14_12	0.821
ANX_POD	15_2, 15_5	0.915

From a methodological perspective, the factor analysis therefore served not merely as a technical procedure but as a tool for gaining a deeper understanding of how different forms of AI-supported learning influence the affective aspects of learning mathematics.

PPV of the AI Assistant

Conceptualization of the construct. The construct PPV was developed to capture the extent to which students perceive the DAK AI assistant as a pedagogically valuable tool in the context of their own learning of arithmetic and their future teaching practice.

Theoretically, the construct was conceptualized as two-dimensional. It was assumed that the perceived value of AI may have the following:

1. an academic dimension, oriented toward supporting the understanding of the subject matter and mastery of mathematical tasks—PPV_DAK_ACAD (academic learning support),
2. a didactic dimension, oriented toward supporting pedagogical confidence and the ability to explain mathematics to pupils—PPV_DAK_DID_IMPACT (didactic impact).

This distinction assumes that AI may influence two different levels: the level of personal academic mastery and the level of the future professional identity of the teacher.

Academic dimension. The PPV_DAK_ACAD dimension included items focusing on the academic benefits of the AI assistant, specifically:

- 9_1 – better understanding of arithmetic content,
- 9_3 – step-by-step guidance in solving mathematical problems,
- 9_4 – assistance with calculating examples,

- 9_5 – support in preparing for tests,
- 9_6 – support for reviewing and consolidating the subject matter, and
- 16_10 – overall improved learning of arithmetic through AI.

The items were rated on a 5-point Likert scale, and the index was calculated as the arithmetic mean of the items.

The internal consistency of the scale (reliability) reached Cronbach's $\alpha \approx 0.90$. Such a high value indicates very strong item homogeneity and suggests that students responded consistently across the different aspects of academic support. The corrected item–total correlations exceeded the recommended threshold of 0.40, confirming that all items contribute substantially to the common construct.

From a psychometric perspective, this represents a very strong scale with a high level of internal reliability.

An EFA identified one dominant factor with high factor loadings for all items. The absence of significant cross-loadings supports the interpretation that the academic support provided by the AI assistant represents a single and consistent dimension of perceived pedagogical benefit.

This means that academic support is perceived by students as a unified and coherent phenomenon, encompassing understanding of the subject matter, guidance in problem-solving, and preparation for assessment as interconnected aspects of a single dimension.

The results suggest that students do not perceive the individual functions of the AI assistant in isolation. Step-by-step guidance, explanation of the subject matter, and support for test preparation form part of a single integrated perception of academic support. This dimension therefore represents a stable and clearly defined construct that is methodologically robust and theoretically justified.

Didactic dimension. The PPV_DAK_DID_IMPACT dimension focused on the pedagogical extension of using the AI assistant. It included items reflecting the following:

- 9_2 – better understanding of how to explain mathematics to pupils, and
- 9_7 – support in creating didactic activities and lesson preparations.

This dimension captures the transition from personal learning to future teaching practice. After reducing the scale to two conceptually coherent items, the reliability reached Cronbach's $\alpha = 0.611$. Although this value is lower than that of the academic support dimension, it is methodologically acceptable given:

- the small number of items (Cronbach's alpha is sensitive to the number of items),
- the clear conceptual unity of the construct, and
- the conceptual specificity of the dimension.

Table 3. Reliability of the PPV dimensions

Index	Construct	Items	Cronbach's α
PPV_DAK_ACAD	Academic learning support	9_1, 9_3, 9_4, 9_5, 9_6, 16_10	0.9
PPV_DAK_DID_IMPACT	Didactic impact	9_2, 9_7	0.611

For two-item scales, a value above 0.60 (refer to Table 3) is generally considered acceptable in educational research. The items clustered into a separate factor

distinct from academic support, confirming that students differentiate between the following:

- their own understanding of mathematics, and
- their pedagogical confidence in explaining it.

The didactic impact therefore represents a specific and conceptually distinct dimension. The AI assistant is thus not perceived solely as a tool for learning mathematics but also as a support for future teaching practice. However, this dimension is not as homogeneous as academic support, which may reflect the complexity of the pedagogical identity of future teachers.

Evaluation of construct quality. The psychometric analysis of the constructed indices confirmed their methodological adequacy and theoretical justification.

The following findings were obtained:

- high internal consistency of the global index of anxiety reduction (ANX_MATH_RED),
- a clear two-factor structure of the stress-related construct (ANX_DAK and ANX_POD),
- a very strong and homogeneous construct of academic support (PPV_DAK_ACAD), and
- a separate, theoretically grounded dimension of didactic impact (PPV_DAK_DID_IMPACT).

These results support the assumption that interactive AI support operates primarily through the mechanism of academic mastery of the subject matter, whereas podcasts tend to have a more emotional and stabilizing function. At the same time, the findings indicate that pedagogical confidence represents a distinct, although related, dimension of the perceived value of the AI assistant.

From a methodological perspective, it can therefore be concluded that the constructed constructs:

- demonstrate sufficient internal reliability,
- exhibit a clear factor structure,
- are not redundant, and
- allow for a differentiated analysis of the mechanisms of AI impact.

The constructs PPV_DAK_ACAD and ANX_MATH_RED exhibit the strongest psychometric properties, providing a solid foundation for subsequent correlation, regression, and mediation analyses.

3 METHODOLOGY

3.1 Research design

The present study has a quantitative, exploratory–explanatory character. Its aim was to examine the relationship between the PPV of a specialized AI assistant (DAK) and the reduction of mathematics anxiety among students of primary teacher education. The research design assumes that affective variables (particularly anxiety reduction) may be influenced by the perceived quality of academic and didactic support.

The research was conducted as a post-test questionnaire survey following the completion of the course Primary Mathematics Education—Arithmetic. Within this course, two forms of AI support were systematically implemented:

- The interactive AI assistant DAK, providing step-by-step explanations and feedback, and
- Thematic podcasts generated using AI technologies, intended for reinforcement of the subject matter and preparation for assessment.

The design was non-experimental (it did not include a control group), but it allowed for the analysis of relationships between perceptual and affective constructs within a natural educational environment. Consequently, the study focuses on students' perceived reduction of mathematics anxiety during learning, rather than on an experimentally verified change measured in a pre-post design.

3.2 Research sample

The research population consisted of students enrolled in the Primary Teacher Education study program. A total of 152 students were enrolled in the course. The questionnaire was completed by 90 respondents, representing a response rate of approximately 60%. Of these, 84 respondents reported actively using the DAK AI assistant during the semester.

The analyses were conducted on a subsample of students who declared actual use of AI tools ($N \approx 84 – 86$, depending on the number of missing responses for individual items). The sample selection can be characterized as convenience sampling, since the research was conducted within a specific course and institution.

Although this sampling method limits the generalizability of the results, it allows for a detailed analysis of students' experiences within an authentic pedagogical context.

3.3 Data collection and data processing

Data were collected through an anonymous online questionnaire distributed after the end of the semester. The questionnaire focused on capturing students' subjective evaluations of:

- the perceived reduction of mathematics anxiety,
- the PPV of the AI assistant, and
- their experience with using DAK and podcasts.

The questionnaire included:

- items rated on a 5-point Likert scale,
- dichotomous items (0/1), and
- nominal questions concerning the ways in which AI tools were used.

The self-report nature of the instrument made it possible to capture students' subjective perceptions, which are essential when investigating affective constructs such as mathematics anxiety.

Statistical data analysis was conducted using IBM SPSS. The data processing procedure included the construction of indices and the selection of appropriate statistical

methods in accordance with the research objectives. During the preparation of the manuscript, generative AI (ChatGPT, OpenAI) was occasionally used as a supportive consultation tool for discussing possible analytical approaches and for improving the clarity of the methodological description. All methodological decisions, analyses, and interpretations were made exclusively by the authors.

3.4 Ethical aspects

The study was conducted in accordance with ethical standards for research involving human participants. Ethical approval was granted by the Ethics Committee of the Catholic University of Ružomberok (Decision No. 9/2025, ref. CZ 03986/2025 RE; approved on 10 October 2025).

Participants were fully informed about the purpose of the study, the voluntary nature of their participation, and the anonymous processing of their responses. Informed consent was obtained from all participants—the questionnaire included a statement informing participants that by completing the questionnaire, they consented to the processing of their responses for research purposes.

No personally identifiable data were collected.

3.5 Operationalization of variables

The operationalization was based on the theoretical conceptualization presented in Section 2. The following indices were constructed:

Reduction of mathematics anxiety. The construct of mathematics anxiety reduction was operationalized using six Likert-scale items capturing a decrease in stress:

- as a result of using the interactive AI assistant DAK,
- as a result of using podcasts, and
- a global evaluation of the impact of AI tools on mathematics-related stress.

Based on the results of the factor analysis, three indices were created:

- ANX_MATH_RED – global index of mathematics anxiety reduction,
- ANX_DAK – reduction of stress mediated by the interactive AI assistant, and
- ANX_POD – reduction of stress mediated by podcasts.

The indices were calculated as the arithmetic mean of the respective items.

PPV of the AI assistant. The PPV construct was divided into two dimensions:

- PPV_DAK_ACAD – academic learning support (understanding of the subject matter, step-by-step guidance, preparation for assessment, and consolidation of learning), and
- PPV_DAK_DID_IMPACT – didactic impact (support for explaining mathematics to pupils and for designing didactic activities).

These indices were also calculated as the arithmetic mean of the corresponding items. The variables constructed in this way made it possible to test the assumed relationships between the perceived quality of AI-supported learning and the reduction of mathematics anxiety.

3.6 Analytical procedure

The analysis was conducted in several consecutive steps.

Descriptive analysis. First, basic descriptive statistics (means and standard deviations) were calculated to provide an overview of the distribution of responses.

Psychometric validation of constructs. To assess the reliability and validity of the constructed indices, the following methods were used:

- Cronbach's alpha coefficient to evaluate internal consistency,
- EFA (PAF with Oblimin rotation) to verify the latent structure of the constructs.

This step made it possible to identify separate dimensions of anxiety reduction and the PPV of the AI assistant.

Correlation analysis. Relationships between the ANX and PPV indices were analyzed using the Pearson correlation coefficient. The aim was to examine the strength and direction of associations between the perceived academic and didactic support and the reduction of mathematics anxiety.

Regression and mediation analysis. To test the predictive relationship and the potential mechanism of the effect of AI support, a linear regression analysis was conducted, followed by a mediation model (PPV_DAK_ACAD → ANX_DAK → ANX_MATH_RED).

3.7 Methodological limitations

The results should be interpreted in the context of several methodological limitations:

- The research is based on self-report data, which may lead to social desirability bias.
- The sample originates from a single institution and one study program.
- The design is correlational and therefore does not allow for drawing unambiguous causal conclusions.

Despite these limitations, the study provides valuable empirical insight into the relationship between AI-supported learning and the affective aspects of learning mathematics in the context of future teacher education.

4 RESULTS

4.1 Research hypotheses

Based on the theoretical framework and the psychometric validation of the constructs, the following research hypotheses were formulated:

H1: The perceived academic support of the AI assistant (PPV_DAK_ACAD) is positively associated with the global reduction of mathematics anxiety (ANX_MATH_RED).

H2: The perceived didactic impact of the AI assistant (PPV_DAK_DID_IMPACT) is positively associated with the reduction of mathematics anxiety, but to a lesser extent than academic support.

H3: The reduction of anxiety mediated by the interactive AI assistant (ANX_DAK) shows stronger associations with PPV indices than the reduction of anxiety mediated by podcasts (ANX_POD).

H4: The academic support of the AI assistant (PPV_DAK_ACAD) represents a significant predictor of mathematics anxiety reduction even after controlling for didactic impact.

These hypotheses reflect the assumption that the effect of AI on affective variables is not random but is mediated by the perceived quality of academic support.

4.2 Correlation analysis

The relationships between the indices were analyzed using the Pearson correlation coefficient (refer to Table 4).

Table 4. Correlations between ANX and PPV indices

		Academic Support (PPV_DAK_ACAD)	Didactic Impact (PPV_DAK_DID_IMPACT)
Stress reduction due to the AI assistant DAK (ANX_DAK)	Pearson Correl.	0.723	0.536
	Sig. (2-tailed)	0	0
Stress reduction due to podcasts (ANX_POD)	Pearson Correl.	0.463	0.313
	Sig. (2-tailed)	0	0.004
Perceived reduction of mathematics anxiety due to AI (ANX_MATH_RED)	Pearson Correl.	0.723	0.518
	Sig. (2-tailed)	0	0

Interpretation of correlations. The results clearly support Hypothesis H1. The academic support of the AI assistant shows a strong positive correlation with the global reduction of mathematics anxiety ($r = 0.723$). This relationship can be interpreted as a high level of interconnectedness between the sense of mastery of the subject matter and the reduction of stress.

Hypothesis H2 is also supported. Although the didactic impact is significantly associated with the overall reduction of anxiety ($r = 0.518$), the correlation is systematically weaker than that observed for academic support. This suggests that the development of pedagogical confidence plays a role, but it is not the primary mechanism of stress reduction.

Hypothesis H3 is confirmed. ANX_DAK shows stronger correlations with the PPV indices ($r = 0.723$ and 0.536) than ANX_POD ($r = 0.463$ and 0.313). The reduction of stress mediated by the interactive AI assistant therefore exhibits substantially stronger associations with the PPV indices than podcast-based support. This finding supports the assumption that interactive, step-by-step feedback has a more robust affective impact than a passive form of support.

4.3 Regression analysis

To verify the predictive strength of the individual dimensions of the PPV of the AI assistant, a linear regression analysis was conducted. While the correlation analysis

allowed the identification of the strength and direction of relationships between variables, regression analysis makes it possible to determine to what extent these variables explain the variability in the reduction of mathematics anxiety.

The aim of this analysis was to determine whether:

- academic support (PPV_DAK_ACAD)
- didactic impact (PPV_DAK_DID_IMPACT)

represent significant predictors of the global reduction of mathematics anxiety (ANX_MATH_RED), and which of these predictors has the dominant effect.

The regression model was tested using the enter method (simultaneous inclusion of predictors), with ANX_MATH_RED defined as the dependent variable.

Model results. The regression model (see Table 5) was statistically significant ($p < 0.001$) and explained approximately 52% of the variance in mathematics anxiety reduction ($R^2 \approx 0.52$).

Table 5. Standardized regression coefficients

Predictor	β	p	R^2
PPV_DAK_ACAD	**0.61**	<0.001	0.52
PPV_DAK_DID_IMPACT	0.18	0.041	0.56

Note: Bold value indicates the strongest standardized regression coefficient in the model.

Interpretation of the regression model. The results confirm Hypothesis H4. Academic support remains the dominant predictor of the reduction of mathematics anxiety even after controlling for didactic impact. The standardized coefficient $\beta = 0.61$ indicates a strong effect.

The didactic impact is statistically significant, but its effect is substantially weaker ($\beta = 0.18$). This difference should also be interpreted in the context of the psychometric properties of the scales. The didactic impact dimension was measured using a two-item scale with lower internal reliability (Cronbach's $\alpha = 0.611$), which may naturally limit its predictive strength in comparison with the more robust academic support dimension. This suggests that the reduction of anxiety is primarily associated with the subjective sense of mastering the subject matter, rather than solely with the development of pedagogical identity. At the same time, the statistical significance of the didactic dimension despite its lower reliability suggests that the observed relationship may represent a conservative estimate of its actual effect.

The results suggest the following interpreted mechanism:

- The AI assistant provides structured, step-by-step explanations.
- The student may experience a stronger sense of understanding and control over the problem-solving process.
- This experience may strengthen the perceived mastery of the subject matter.
- The strengthened sense of mastery is associated with a reported reduction of mathematics anxiety.

Although podcasts also reduce stress, their effect is weaker and less closely associated with the perception of academic support. They likely operate more through emotional comfort than through cognitive mastery.

4.4 Extended regression model

Assumption testing. To examine the relative contribution of the individual dimensions of the PPV of the AI assistant, a hierarchical regression analysis was subsequently conducted. This procedure allows predictors to be entered into the model step by step and makes it possible to observe the additional explained variance contributed by each predictor.

In the first step, the dominant theoretical predictor—academic support (PPV_DAK_ACAD)—was entered into the model. In the second step, didactic impact (PPV_DAK_DID_IMPACT) was added in order to determine whether this dimension explains an additional portion of the variance in mathematics anxiety reduction beyond academic support.

Before conducting the regression analysis, the basic assumptions of the linear model were verified (linearity, normality of residuals, homoscedasticity, and multicollinearity), ensuring the methodological robustness of the results.

Linearity of the relationship—the scatterplot indicated a linear trend between PPV_DAK_ACAD and ANX_MATH_RED.

- Normality of residuals – the histogram and P–P plot indicated approximate normality.
- Homoscedasticity – the variance of residuals was evenly distributed.
- Multicollinearity – *VIF* < 2 for both predictors, indicating low collinearity.

The model can therefore be considered methodologically stable.

Interpretation. Even after including didactic impact, academic support remains the dominant predictor. The didactic impact adds a small but statistically significant amount of additional explained variance.

4.5 Mediation: mechanism of AI impact

Correlation and regression analyses indicated a strong association between the perceived academic support and the reduction of mathematics anxiety. From a theoretical perspective, however, it is not sufficient to establish the existence of a relationship; it is also necessary to examine its possible underlying mechanism.

Based on the mastery-based model of anxiety reduction, a mediation model was therefore tested. The model assumes that the effect of perceived academic support (PPV_DAK_ACAD) on the global reduction of mathematics anxiety (ANX_MATH_RED) is mediated by the reduction of stress when working with the interactive AI assistant (ANX_DAK).

- PPV_DAK_ACAD → ANX_DAK
  $\beta \approx 0.72$, $p < 0.001$
- ANX_DAK → ANX_MATH_RED
  $\beta \approx 0.83$, $p < 0.001$
- Direct effect: PPV_DAK_ACAD → ANX_MATH_RED

The coefficient β decreased after including the mediator (partial mediation).

In other words, it is assumed that AI support first reduces stress during the solving of specific tasks, and this effect subsequently translates into a global decrease in mathematics anxiety.

The mediation was tested using a series of linear regressions and a bootstrap procedure (5000 replications), which allows for a more reliable estimation of the indirect effect without assuming normal distribution. Based on the theoretical model, the following mediation relationship was tested:

PPV_DAK_ACAD → ANX_DAK → ANX_MATH_RED

The indirect effect was statistically significant (the 95% confidence interval did not include zero).

Interpretation of mediation. The results of the mediation analysis suggest that the effect of the AI assistant on the reduction of mathematics anxiety cannot be interpreted as a direct "technological effect." The mere presence of an AI tool does not automatically lead to a reduction in stress. Instead, the reduction of mathematics anxiety is mediated by a specific mechanism that can be interpreted as a process of gradually strengthening academic mastery.

The analysis showed that the perception of academic support (PPV_DAK_ACAD) first significantly increases the reduction of stress when solving specific tasks with the support of the interactive assistant (ANX_DAK). This decrease in situational stress is then reflected in the global reduction of mathematics anxiety (ANX_MATH_RED). After including the mediator, the direct effect of academic support decreased, confirming the presence of partial mediation.

The reduction of stress therefore occurs through the following sequence:

- an increase in the perception of academic support,
- a subsequent reduction of stress during problem-solving (ANX_DAK),
- a global reduction of mathematics anxiety.

The mechanism of AI impact can therefore be interpreted as primarily cognitive (mastery-based), grounded in the growth of a sense of mastery (mastery experience). The reduction of anxiety is not the result of emotional support alone but rather a consequence of an increased sense of control, understanding, and confidence when solving mathematical problems.

4.6 Summary of results

The empirical analysis yielded consistent and theoretically coherent findings. The reduction of mathematics anxiety is strongly and significantly associated with the perceived academic value of the AI assistant. The interactive form of support DAK shows systematically stronger associations with stress reduction than podcasts, indicating different mechanisms of influence for the two forms of AI support.

Regression models confirmed that academic support is the dominant predictor of anxiety reduction, while didactic impact plays a secondary, complementary role. The mediation analysis further indicated that the effect of AI operates through the reduction of situational stress during problem-solving, which subsequently influences the global level of mathematics anxiety.

The tested model (see Figure 1) can therefore be interpreted as a path model describing the relationships between the perception of academic support and the reduction of mathematics anxiety, with situational stress reduction acting as a mediating mechanism. Although the analysis was conducted using regression procedures and composite indices, the conceptual structure of the model is similar to models commonly examined within the framework of structural equation modeling.

The results confirm that:

- the reduction of mathematics anxiety is significantly associated with the perceived academic value of the AI assistant,
- interactive AI support shows a stronger relationship with stress reduction than podcasts, and
- academic support is the dominant predictor of anxiety reduction.

These findings support the theoretical assumption that AI tools in the preparation of future teachers influence the affective aspects of learning primarily through the mechanism of increased mastery of the subject matter. The reduction of anxiety thus results from the strengthening of academic control and self-confidence, rather than merely from the emotional comfort provided by technology.

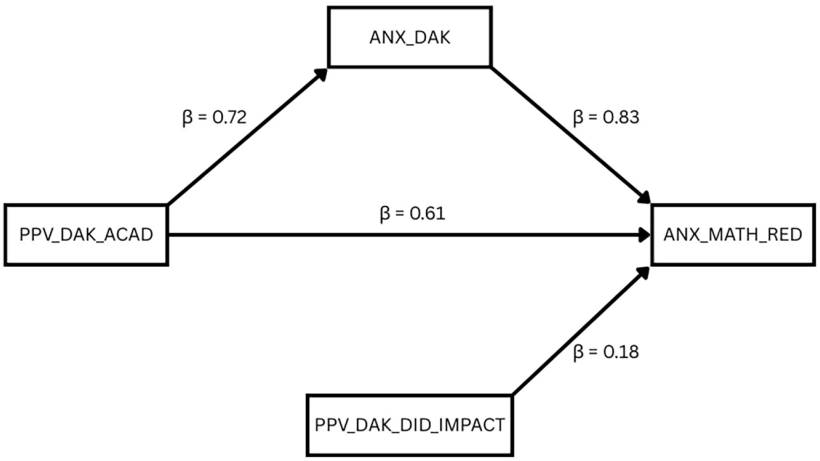

Fig. 1. Path analysis diagram of the relationships between perceived academic support of AI and reduction of mathematics anxiety

5 DISCUSSION AND CONCLUSION

5.1 Interpretation of the main findings

The aim of the study was to examine to what extent the reduction of mathematics anxiety among future primary education teachers is associated with the PPV of an AI assistant and through what mechanism this relationship operates. The results of the empirical analysis confirmed that the perceived reduction of mathematics anxiety is systematically associated with the perception of academic support provided by AI.

The strongest predictor of anxiety reduction was the academic dimension of the perceived value of the DAK AI assistant (PPV_DAK_ACAD). Students who perceived AI as a tool supporting understanding of the subject matter, step-by-step guidance in problem-solving and preparation for assessment simultaneously reported a more pronounced reduction of stress. This relationship was confirmed not only in the correlation analysis, but also in the regression and mediation models.

The didactic impact (PPV_DAK_DID_IMPACT) was also related to anxiety reduction; however, its effect was weaker and secondary. This suggests that the primary mechanism of anxiety reduction is linked to personal academic mastery of the subject matter rather than to the development of pedagogical identity.

At the same time, it was confirmed that interactive AI support DAK shows a stronger relationship with stress reduction than podcasts. Podcasts likely fulfill a supplementary stabilizing function, whereas the interactive assistant operates through active cognitive engagement.

5.2 Theoretical implications

The findings support the mastery-based model of mathematics anxiety reduction, according to which the decrease in anxiety results from an increased sense of control and understanding during problem-solving, which can be schematically expressed as:

Perceived academic support → Increased mastery → Reduced anxiety

The results are consistent with Albert Bandura's self-efficacy theory, according to which the experience of mastering tasks (mastery experience) represents a key source of confidence and regulation of stress during learning [15], [25]. An AI assistant that provides structured and step-by-step explanations likely increases the perception of control over problem-solving, thereby indirectly reducing anxiety. A similar mechanism has also been identified in research on mathematics anxiety, which shows that a supportive learning environment that reduces cognitive load and strengthens the perception of competence leads to lower levels of stress during problem solving [3], [28].

The study also highlights the need to differentiate between different types of AI-supported learning. An interactive, dialogic form of support has a different affective impact than passively consumed content, as active engagement and immediate feedback are associated with a higher perception of academic support and lower levels of anxiety [29], [30]. This differentiation has both methodological and theoretical significance, as it demonstrates that the effect of AI should not be understood as a homogeneous phenomenon but rather as the result of specific pedagogical mechanisms.

Conceptually, the findings can be interpreted within the framework of structural equation modeling, where the perception of academic support influences mathematics anxiety both directly and indirectly—through the reduction of situational stress. Such an approach is frequently used in educational research to examine complex relationships between affective and cognitive variables and allows the identification of mediating mechanisms of learning [31], [32].

5.3 Practical implications for teacher education

From a practical perspective, the findings have several important implications.

First, the implementation of AI tools in the preparation of future teachers should not primarily focus on generating ready-made solutions but rather on supporting procedural understanding. Key elements include step-by-step guidance, explanation of procedures, and the possibility to work safely with errors.

Second, the reduction of mathematics anxiety is closely linked to the sense of mastery of the subject matter. AI tools may function as a support mechanism for building academic confidence, which is particularly important in the context of teacher education, where future teachers will themselves teach mathematics.

Third, podcasts can be considered a suitable complement to interactive support. They may contribute to emotional comfort, reinforcement of the subject matter, and flexibility of preparation, but they do not by themselves replace interactive cognitive scaffolding, which can be provided by an appropriately designed AI assistant (such as the author-developed DAK assistant).

Fourth, the integration of AI into teacher education should be didactically grounded. Technological innovation without a clear pedagogical framework does not necessarily lead to the reduction of affective barriers in learning mathematics.

5.4 Limitations of the study

The results should be interpreted in the context of several limitations.

1. Although the number of active users included in the analyses ($N \approx 84 – 86$) is relatively modest for advanced statistical procedures, the data met the assumptions for factor analysis (KMO = 0.780; Bartlett's test $p < 0.001$), and the resulting factor structure explained 70.7% of the variance with satisfactory reliability of the indices. Nevertheless, future studies should verify the model on larger samples.
2. The data are based on self-report responses. Although this is an appropriate approach when measuring affective constructs, the influence of social desirability bias or subjective interpretation of items cannot be excluded.
3. The design is correlational. Although the mediation model suggests a possible mechanism, causality cannot be definitively established. The findings should therefore be interpreted as associations between perceived academic support and perceived reductions in anxiety, rather than as experimentally verified causal effects.
4. The study was conducted within a single institution and national context (teacher education in Slovakia), which may limit the transferability of the findings to other educational systems. However, the identified mechanism – the link between perceived academic support, mastery experiences, and anxiety reduction – is theoretically based on widely established frameworks (e.g., self-efficacy theory and models of mathematics anxiety). Therefore, it is likely that the underlying mechanism can be generalized to other educational contexts, although its strength and manifestation may vary depending on cultural, institutional, and technological conditions.
5. The model worked with composite indices rather than fully latent SEM models, which would explicitly account for measurement error.

5.5 Recommendations for future research

Future research should focus on:

- longitudinal monitoring of the development of mathematics anxiety during teacher education,
- experimental verification of the effects of AI support using a control group,
- linking anxiety reduction with objective mathematical performance,
- analyzing the interaction between anxiety reduction and pedagogical self-confidence, and
- testing a full latent structural equation model (SEM) on a larger sample.

Another promising direction is to examine whether the reduction of anxiety among future teachers subsequently influences their teaching behavior and pupils' attitudes toward mathematics.

5.6 Final evaluation

The present study provides empirical evidence that a specialized AI assistant implemented in teacher education is associated with a perceived reduction of mathematics anxiety through the mechanism of increased academic mastery of the subject matter.

The reduction of anxiety was found to be systematically associated with the perception of academic support, while interactive AI support demonstrated a stronger affective impact than passive forms of support. The mechanism of this effect can be interpreted as a process of strengthening control, understanding, and self-confidence.

The findings suggest that AI in the preparation of future teachers can play not only a cognitive but also a significant affective role. When implemented with careful instructional design, it may contribute to reducing emotional barriers associated with learning mathematics, thereby indirectly supporting the quality of future pedagogical practice.

6 ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Grant Agency of the Faculty of Education of the Catholic University in Ružomberok for financial support for publication purposes through the allocation of an internal grant supporting creative scientific activity, as well as the KEGA grant No. 004KU-4/2025 Osobnosti slovenskej matematiky III.

7 DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) as a supportive tool to improve the clarity and readability of the text and to discuss possible ways of presenting methodological procedures. The authors carefully reviewed and edited all outputs generated by the tool and take full responsibility for the final content of the publication.

8 REFERENCES

[1] M. H. Ashcraft, "Math anxiety: Personal, educational, and cognitive consequences," *Current Directions in Psychological Science*, vol. 11, no. 5, pp. 181–185, 2002. https://doi.org/10.1111/1467-8721.00196

[2] E. A. Maloney and S. L. Beilock, "Math anxiety: Who has it, why it develops, and how to guard against it," *Trends in Cognitive Sciences*, vol. 16, no. 8, pp. 404–406, 2012. https://doi.org/10.1016/j.tics.2012.06.008

[3] M. H. Ashcraft and J. A. Krause, "Working memory, math performance, and math anxiety," *Psychonomic Bulletin & Review*, vol. 14, no. 2, pp. 243–248, 2007. https://doi.org/10.3758/BF03194059

[4] R. Hembree, "The nature, effects, and relief of mathematics anxiety," *Journal for Research in Mathematics Education*, vol. 21, no. 1, pp. 33–46, 1990. https://doi.org/10.2307/749455

[5] S. L. Beilock, E. A. Gunderson, G. Ramirez, and S. C. Levine, "Female teachers' math anxiety affects girls' math achievement," *Proceedings of the National Academy of Sciences*, vol. 107, no. 5, pp. 1860–1863, 2010. https://doi.org/10.1073/pnas.0910967107

[6] S. L. Swars, C. J. Daane, and J. Giesen, "Mathematics anxiety and mathematics teacher efficacy," *School Science and Mathematics*, vol. 107, no. 7, pp. 264–271, 2007. https://doi.org/10.1111/j.1949-8594.2006.tb17921.x

[7] G. Gresham, "Mathematics anxiety and mathematics teacher efficacy in elementary preservice teachers," *Teaching Education*, vol. 19, no. 3, pp. 171–184, 2008. https://doi.org/10.1080/10476210802250133

[8] T. Jablonský, I. Emmerová, and M. Balážová, "Values and value orientations in the teaching profession and teacher education," *TEM Journal: Technology, Education, Management, Informatics*, vol. 14, no. 4, pp. 3815–3822, 2025. https://doi.org/10.18421/TEM144-84

[9] G. Polydoros *et al.*, "Innovative AI-driven approaches to mitigate math anxiety and enhance resilience among students with persistently low performance in mathematics," *Psychology International*, vol. 7, no. 2, p. 46, 2025. https://doi.org/10.3390/psycholint7020046

[10] F. Gabriel, J. Kennedy, R. Marrone, and S. Leonard, "Pragmatic AI in education and its role in mathematics learning and teaching," *npj Science of Learning*, vol. 10, p. 26, 2025. https://doi.org/10.1038/s41539-025-00315-4

[11] Z. Huľová, P. Tokoš, E. Bolčová, R. Hrmo, and L. Krištofiaková, "Creating a battery of subtests to measure students' skills in technical education," *TEM Journal*, vol. 13, no. 4, pp. 3405–3412, 2024. https://doi.org/10.18421/TEM134-74

[12] Z. Huľová, P. Tokoš, and E. Bolčová, "Verification of the impact of the distance education program on the development of students' skills," *TEM Journal: Technology, Education, Management, Informatics*, vol. 13, no. 4, pp. 3186–3193, 2024. https://doi.org/10.18421/TEM134-53

[13] Š. Tkačik, D. Babicová, and Š. Tkačik Jr., "Potenciál a limity integrácie AI v matematickej príprave budúcich učiteľov primárneho vzdelávania," *Disputationes Scientificae Universitatis Catholicae In Ružomberok*, vol. XXVI, no. 1, pp. 93–110, 2026. https://doi.org/10.54937/dspt.2026.26.1.93-110

[14] F. C. Richardson and R. M. Suinn, "The mathematics anxiety rating scale," *Journal of Counseling Psychology*, vol. 19, no. 6, pp. 551–554, 1972. https://doi.org/10.1037/h0033456

[15] A. Bandura, *Self-Efficacy: The Exercise of Control*. New York, NY: Freeman, 1997.

[16] S. Papadakis *et al.*, "Advancing lifelong learning with AI-enhanced ICT: A review of emerging educational practices," in *CEUR Workshop Proceedings*, 2024.

[17] S. Papadakis, *Teaching with Artificial Intelligence: A Guide for Primary and Elementary Educators*. London: Routledge, 2025, p. 260. https://doi.org/10.4324/9781003685241

[18] P. Vankúš, "Generative artificial intelligence on mobile devices in the university preparation of future teachers of mathematics," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 18, no. 18, pp. 19–33, 2024. https://doi.org/10.3991/ijim.v18i18.51221

[19] A. Ajlouni *et al.*, "The intensity of using ChatGPT in relation to academic stress: A cross-sectional study," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 19, no. 17, pp. 81–100, 2025. https://doi.org/10.3991/ijim.v19i17.56495

[20] D. Babicová, "Integrácia generatívnej umelej inteligencie do matematickej prípravy budúcich učiteliek primárneho vzdelávania," *Acta Mathematica Nitriensia*, vol. 9, no. 1, pp. 8–18, 2025. https://doi.org/10.17846/AMN.2025.9.1.8-18

[21] T. D. T. Pham *et al.*, "Designing an AI-supported formative assessment model for pre-service mathematics teacher self-study in Vietnam," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 19, no. 22, pp. 50–68, 2025. https://doi.org/10.3991/ijim.v19i22.57723

[22] L. Csachová and A. Šimšíková, "Scaffolding ako didaktický prostriedok v riešiteľskom procese matematických úloh," *Acta Mathematica Nitriensia*, vol. 10, no. 1, pp. 18–30, 2026. https://doi.org/10.17846/AMN.2026.10.1.18-30

[23] J. Van de Pol, M. Volman, and J. Beishuizen, "Scaffolding in teacher–student interaction: A decade of research," *Educational Psychology Review*, vol. 22, pp. 271–296, 2010. https://doi.org/10.1007/s10648-010-9127-6

[24] D. Wood, J. S. Bruner, and G. Ross, "The role of tutoring in problem solving," *Journal of Child Psychology and Psychiatry*, vol. 17, no. 2, pp. 89–100, 1976. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x

[25] F. Pajares, "Self-efficacy beliefs in academic settings," *Review of Educational Research*, vol. 66, no. 4, pp. 543–578, 1996. https://doi.org/10.3102/00346543066004543

[26] W. Ahmed *et al.*, "Reciprocal relationships between math self-concept and math anxiety," *Learning and Individual Differences*, vol. 22, no. 3, pp. 385–389, 2012. https://doi.org/10.1016/j.lindif.2011.12.004

[27] F. Pajares and M. D. Miller, "Role of self-efficacy and self-concept beliefs in mathematical problem solving," *Journal of Educational Psychology*, vol. 86, no. 2, pp. 193–203, 1994. https://doi.org/10.1037/0022-0663.86.2.193

[28] G. Ramirez, S. T. Shaw, and F. A. Maloney, "Math anxiety: Past research, promising interventions, and a new interpretation framework," *Educational Psychologist*, vol. 53, no. 3, pp. 145–164, 2018. https://doi.org/10.1080/00461520.2018.1447384

[29] K. VanLehn, "The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems," *Educational Psychologist*, vol. 46, no. 4, pp. 197–221, 2011. https://doi.org/10.1080/00461520.2011.611369

[30] W. Holmes, M. Bialik, and C. Fadel, "Artificial intelligence in education: Promises and implications for teaching and learning," Center for Curriculum Redesign, 2019.

[31] R. B. Kline, *Principles and Practice of Structural Equation Modeling*, 4th ed. New York, NY: Guilford Press, 2016.

[32] J. B. Schreiber *et al.*, "Reporting structural equation modeling and confirmatory factor analysis results," *The Journal of Educational Research*, vol. 99, no. 6, pp. 323–338, 2006. https://doi.org/10.3200/JOER.99.6.323-338

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