TEM Journal. Volume 15, Issue 3, pages 2801-2810, ISSN 2217-8309, DOI: 10.18421/TEM153-65, August 2026.

Predictors of the Effective Implementation of Artificial Intelligence Tools in Mathematics Education of Pre-Service Primary Teachers

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Abstract **– Previous research suggests that math anxiety is common among prospective teachers, is associated with less positive attitudes toward math, and may later affect their students. At the same time, AI tools and educational podcasts appear promising for personalized support of self-study in mathematics education. The aim of this study is to establish a baseline profile of selected predictors prior to the planned implementation of an AI assistant for self-study in mathematics. Five research questions examined the relationships between five composite indices and potential differences according to patterns of student AI use. It was hypothesized that math anxiety would be negatively correlated with attitudes toward math, that openness to AI integration would be positively related to skills in using AI, and that students with higher AI skills would exhibit more favorable attitudes toward podcasts. A questionnaire-based pre-test was conducted with prospective first-year primary school teachers in the first year of a master's program. Composite indices were developed and their reliability was verified. The results confirmed the expected correlations and highlighted significant differences between AI users and non-users, particularly regarding openness to AI and knowledge in this area.**

DOI: 10.18421/TEM153-65
https://doi.org/10.18421/TEM153-65

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Received: 27 January 2026.
Revised: 11 April 2026.
Accepted: 22 April 2026.
Published: 27 August 2026.

Keywords **– AI assistant, pre-service teachers, anxiety and attitude toward mathematics, podcasts.**

1. Introduction

Primary mathematics education plays a key role in shaping basic mathematical concepts, developing mathematical thinking, and forming pupils' attitudes toward mathematics. Research has consistently shown that the early stages of education are where foundations are established that significantly influence pupils' later relationship with mathematics, their self-confidence in solving mathematical tasks, and their level of mathematics anxiety [1], [2]. Negative experiences with mathematics in primary education may be transferred to subsequent levels of education and can have a long-term impact on academic performance as well as on pupils' success in STEM-related fields [3], [4].

In primary education, the teacher plays a crucial role not only in conveying mathematical content but also in shaping pupils' attitudes toward mathematics [3], [5], [6], [7]. Research also indicates that mathematics anxiety is particularly prevalent among pre-service primary teachers and is often linked to negative experiences from their own schooling [8]. This phenomenon is especially problematic because the anxiety of future teachers may be indirectly transmitted to their pupils. Studies have shown that mathematics anxiety among female primary school teachers negatively affect the performance and attitudes of female pupils toward mathematics [9].

Mathematics anxiety is commonly defined as feelings of fear and tension associated with mathematics that undermine self-confidence and lead to the avoidance of mathematical tasks [10], [11]. It is a widespread phenomenon with a demonstrably negative impact on both the learning process and achieved performance. Meta-analytic studies confirm a moderately strong negative correlation between mathematics anxiety and achievement in mathematics ($r \approx -0.3$) across different age groups [12].

For these reasons, the scholarly literature emphasizes the need to systematically address the reduction of mathematics anxiety during teacher education. Longitudinal studies suggest that appropriately designed didactic interventions in pre-service education can lead to positive changes in emotional, cognitive, and self-evaluative dimensions, including both mathematical and didactic self-efficacy, with improvements in one area typically reflected in others as well [13], [14].

In recent years, generative artificial intelligence tools have become a common part of students' study strategies, bringing new opportunities for learning support as well as new challenges, particularly in the mathematical preparation of future teachers [17], [18], [22]. In teacher education contexts, their use appears especially promising in the area of self-study, where they can be employed for concept explanation, support in problem solving, example generation, or the provision of immediate feedback. Specially designed, personalized AI chatbots grounded in proprietary resources appear to be the most effective for reducing mathematics anxiety and increasing student achievement [19], [20], [21]. Moreover, generative AI tools enable the creation of educational podcasts directly from one's own study materials, opening new possibilities for personalized support of self-study. Research and practical experience confirm that the use of audio podcasts can support learning through flexibility, motivational effects, and alignment with different student learning styles [20], [23].

At the same time, it is necessary to consider that students enter higher education with differing levels of technological readiness. For the current generation, digital technologies are a natural part of everyday life, which is reflected in higher technological proficiency and specific study strategies compared to previous generations. Mapping students' technological readiness, attitudes, and experiences through questionnaire-based surveys therefore represents an appropriate methodological approach when introducing pedagogical innovations and new forms of instruction [15], [16]. The successful implementation of an AI assistant depends on how students perceive the technology, what skills they have in using it, and what attitudes they hold toward learning mathematics, which may be accompanied by higher levels of anxiety. Research highlights the need to develop comprehensive AI competencies among future teachers, encompassing not only technical skills but also critical and ethical understanding of AI use in education [25].

For these reasons, the study focused on the systematic profiling of students whose instruction is planned to include the didactically thoughtful integration of AI tools.

The first partial results of this pre-test were published in study [22], which examined the relationship between AI tool usage and openness to AI use, AI usage skills, and attitudes toward podcasts. The present study builds on these findings and extends them with additional results.

2. Objectives and Research Questions

The aim of the conducted pre-test was to obtain a baseline profile of students in pre-service primary teacher education in the course Primary Mathematics Education – Arithmetic. These baseline findings provide a foundation for the targeted implementation of a personalized AI assistant and AI-generated podcasts in instruction, as well as for the construction of reliable indices enabling subsequent evaluation of the effectiveness of this self-study support.

Within the research design, three main objectives are defined:

1. To construct and verify the reliability of five composite indices representing key areas examined in the original pre-test questionnaire, specifically mathematics anxiety (ANX_MATH), attitude toward mathematics (ATT_MATH), attitude toward podcasts as a learning tool (POD_LEARN), openness to AI integration (AI_OPEN), and AI usage skills (AI_SKILL),
2. To describe the basic characteristics of the constructed indices and simultaneously verify the suitability of the statistical procedures to be used in evaluating relationships between variables and in comparing groups,
3. To analyse relationships between the indices and selected contextual variables, as well as differences according to AI usage.

Based on these objectives, the following research questions were formulated:

RQ1: *Is mathematics anxiety related to attitudes toward mathematics?*

RQ2: *Is openness to AI integration related to AI usage skills?*

RQ3: *Is the attitude toward podcasts more positive among students with higher AI skills?*

RQ4: *Do the indices differ according to AI usage (users vs. non-users)?*

RQ5: *Is age related to AI usage skills?*

3. Methodology

Research sample and data processing: The research sample consisted of first-year students of the master's degree program *Teacher Education for Primary Education* enrolled in the course *Primary Mathematics Education – Arithmetic*.

Data collection took place at the beginning of the winter semester of the 2025/2026 academic year. A total of 112 students completed the questionnaire, and the obtained responses represented a baseline ("pre-test") profile prior to the planned implementation of personalized AI tools as support for self-study.

Data analysis was conducted using IBM SPSS Statistics, following the methodological procedures described in [24].

The data processing procedure, including index construction and the selection of statistical methods, was continuously consulted with the assistance of the language model ChatGPT (version 5.2; OpenAI), which served as a supportive tool in methodological decision-making.

Indices and reliability: Based on the content logic of the items, composite indices (scale-type variables) were constructed to represent five examined domains:

- ANX_MATH – mathematics anxiety
- ATT_MATH – attitude toward mathematics
- POD_LEARN – attitude toward podcasts as a learning tool
- AI_OPEN – openness to AI integration
- AI_SKILL – AI usage skills

The reliability (internal consistency) of the indices was assessed using Cronbach's alpha (α) (Table 1).

Table 1. Reliability of indices (Cronbach's alpha)

Index	Items	Cronbach's alpha
ANX_MATH – mathematics anxiety	7, 8, 10, 11, 12	0,849
ATT_MATH – attitude toward mathematics	5, 6, 9, 13, 14, 15	0,772
POD_LEARN – attitude toward podcasts as a learning tool	16, 17, 18, 19	0,747
AI_OPEN – openness to AI integration	43, 44, 45, 46	0,626
AI_SKILL – AI usage skills	20, 37, 38, 39, 40, 41, 42	0,690

The interpretation of the reliability coefficients indicates that the ANX_MATH, ATT_MATH, and POD_LEARN indices demonstrate good internal consistency, the AI_SKILL index can be considered acceptable, and the AI_OPEN index shows a lower value which, given the smaller number of items, is still defensible in pedagogical research. For this reason, all indices were retained for further analyses.

Missing responses were coded in IBM SPSS Statistics as user-defined missing values (99) and were excluded from the statistical analyses.

Descriptive statistics and test selection: For each index, basic descriptive characteristics were first calculated, the mean and standard deviation (Table 2).

Table 2. Descriptive characteristics of the indices

Index	Average	Standard deviation
ANX_MATH – mathematics anxiety	3,680	1,049
ATT_MATH – attitude toward mathematics	3,691	0,719
POD_LEARN – attitude toward podcasts as a learning tool	3,946	0,797
AI_OPEN – openness to AI integration	1,302	0,533
AI_SKILL – AI usage skills	0,892	0,399

Subsequently, the normality of the index distributions was assessed using the Shapiro–Wilk test. For all indices, deviations from normal distribution were statistically significant (e.g., AI_OPEN $p < 0.001$; POD_LEARN $p < 0.001$), which led to the selection of nonparametric statistical methods. Accordingly, the following analyses were used:

1. Correlations: Spearman's ρ,
2. Comparison of two groups: Mann–Whitney U test,
3. Comparison of three or more groups: Kruskal–Walli's test (with subsequent post hoc comparisons using the Mann–Whitney test and Bonferroni correction).

This methodological approach ensured that inferential conclusions were based on statistical methods appropriate to the nature of the data and their distribution.

4. Results

As the distributions of all indices deviated significantly from normality, relationships among the five constructed indices were analysed using Spearman's rank correlation coefficient (ρ). The correlation analysis revealed three statistically significant relationships that are also substantively meaningful and support the interpretative consistency of the constructed constructs (Table 3).

Table 3. Significant correlations between indices (Spearman's ρ)

Pair of indices	*P*	*p*	Interpretation
ANX_MATH × ATT_MATH	–0,404	<0,001	Higher mathematics anxiety ↔ less positive attitude toward mathematics
AI_OPEN × AI_SKILL	0,283	0,003	Greater openness to AI ↔ higher AI usage skills
AI_SKILL × POD_LEARN	0,240	0,011	Higher AI usage skills ↔ more positive attitude toward podcasts

RQ1: Is mathematics anxiety related to attitudes toward mathematics?

The analysis revealed a moderately strong negative relationship between mathematics anxiety (ANX_MATH) and attitudes toward mathematics ($\rho = -0.404$; $p < 0.001$). In other words, the results support the assumption that mathematics anxiety and attitudes toward mathematics are closely linked, with higher levels of anxiety being associated with less positive attitudes toward mathematics and potentially limiting students' willingness to actively engage in mathematical learning.

Research question RQ1 was confirmed.

RQ2: Is openness to AI integration related to AI usage skills?

A weak to moderate positive relationship was identified between openness to AI integration (AI_OPEN) and AI usage skills (AI_SKILL) ($\rho = 0.283$; $p = 0.003$). This positive association suggests that openness to AI integration and practical skills in using AI tend to reinforce each other, which has important implications for the design of didactic interventions aimed at developing AI competencies. At the same time, the correlation is not strong, which is noteworthy: Openness to AI does not automatically imply a high level of competence and may also reflect an attitudinal agreement without sufficient experience or training.

Research question RQ2 was confirmed.

RQ3: Is the attitude toward podcasts more positive among students with higher AI skills?

To examine whether attitudes toward podcasts vary with AI usage skills, respondents were divided into three groups based on the AI_SKILL index (low/medium/high skills). Differences in the POD_LEARN index were tested using the Kruskal–Walli's test, which revealed a statistically significant difference among the groups:

$$H = 7.036;\ p = 0.030;\ \eta^2 \approx 0.047.$$

The effect size ($\eta^2 \approx 0.047$) represents a small to moderate effect, which is common for educational variables but substantively meaningful. Descriptive indicators suggest a consistent trend in which more favorable evaluations of podcasts as a learning tool increase with higher levels of AI skills:

Medians and IQRs by group:
low ($N = 45$): $Mdn = 3.75$; $IQR = 0.75$
medium ($N = 31$): $Mdn = 4.25$; $IQR = 1.50$
high ($N = 35$): $Mdn = 4.25$; $IQR = 1.00$

To identify specific differences between groups, post hoc comparisons were conducted using the Mann–Whitney test. The results indicated that the decisive difference was primarily between the low and high AI skill groups:

low vs high:

$$U = 510.0;\ Z = -2.709;\ p = 0.007;\ r = 0.303.$$

Even after applying the Bonferroni correction ($\alpha = 0.017$), this difference remained statistically significant. The findings therefore support the interpretation that a more positive attitude toward podcasts is characteristic mainly of the group with higher AI skills, while differences between adjacent levels (low–medium, medium–high) are not decisive in this sample.

Research question RQ3 was confirmed.

Although the correlation is relatively weak, it is interpretatively important: Technologically more skilled students tend to be more receptive to digital forms of learning (e.g., audio content). This finding supports the notion that technological readiness may serve as a more general predictor of the acceptance of modern learning tools.

At the same time, no direct relationships were confirmed between indices related to mathematical experience and attitudes toward mathematics (ANX_MATH, ATT_MATH) and indices related to artificial intelligence (AI_OPEN, AI_SKILL) ($\rho \approx 0$; $p > 0.15$). This suggests that, in the examined sample, mathematics anxiety and attitudes toward mathematics operate relatively independently of openness to AI integration in education and self-assessed skills in using AI.

RQ4: Do the indices differ according to AI usage (users vs. non-users)?

The variable measuring the frequency of AI use was recoded into a dichotomous variable (AI_USE_2GR: 0=does not use/experience only; 1=uses daily or occasionally). Group comparisons using the Mann–Whitney U test revealed statistically significant differences in the technological dimension (Table 4).

Table 4. Differences according to AI usage (Mann–Whitney)

Variable	U (Z)	*P*	effect r	Conclusion
AI_SKILL	315,5 (–5,141)	<0,001	0,488	users have higher AI_SKILL
AI_OPEN	488,0 (–3,876)	<0,001	0,368	users have higher AI_OPEN
POD_LEARN	854,5 (–1,153)	0,249	0,109	difference not confirmed

The analysis showed that students who use AI achieve significantly higher levels of AI usage skills (AI_SKILL) than non-users ($p < 0.001$), with an effect size of $r = 0.488$ indicating a medium to large difference. A similarly significant difference was also confirmed for openness to AI integration (AI_OPEN; $p < 0.001$), with a medium-sized effect ($r = 0.368$). Overall, the results indicate a consistent trend: Students who use AI more frequently exhibit not only higher levels of AI-related skills but also more positive attitudes toward its didactic application.

For POD_LEARN, no statistically significant difference was confirmed ($p = 0.249$), and the effect size was small ($r = 0.109$), although the median was higher among AI users. The interpretation is therefore clear: Within this group of students, AI usage alone does not explain differences in attitudes toward podcasts, but it is significantly related to the technological indices AI_SKILL and AI_OPEN.

Research question RQ4 was confirmed for AI_SKILL and AI_OPEN and not confirmed for POD_LEARN.

RQ5: Is age related to AI usage skills?

The next step of the analysis examined whether the values of the constructed indices differed according to selected contextual characteristics of the respondents. The sample included students enrolled in full-time, part-time, and supplementary forms of study, which resulted in considerable age variability among participants. The respondents' ages ranged from 22 to 49 years. The results showed that the form of study, experience working in education, and the type of completed secondary school did not represent significant differentiating factors. This result suggests that the examined technological and attitudinal characteristics do not differ across these respondent categories in a way that would allow these variables to be used as simple criteria for targeting support. Some categories were relatively small (Figure 1 and Figure 2), which reduces the sensitivity of the tests to detect differences.

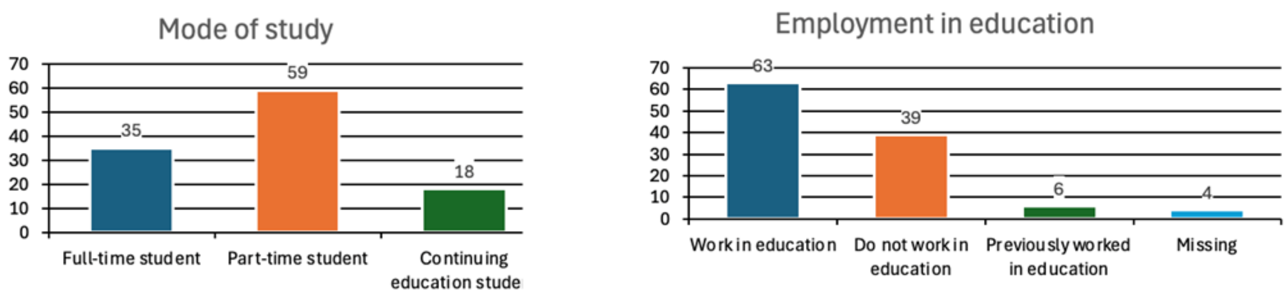

Figure 1. A graph illustrating the distribution of responses across the Mode and Employment categories

Nevertheless, it remains the case that, in practice, these variables cannot be relied upon as straightforward criteria for targeting support.

An exception was age, which was related to AI usage skills.

Spearman's correlation revealed a statistically significant negative relationship between age and AI usage skills:

age × AI_SKILL: $\rho = -0.288;\ p = 0.003.$

Within the examined sample, self-assessed AI usage skills thus slightly decrease with increasing age. This finding has practical significance particularly for planning support, as older students in the group may benefit from more targeted "technological onboarding" when working with an AI assistant.

Research question RQ5 was confirmed.

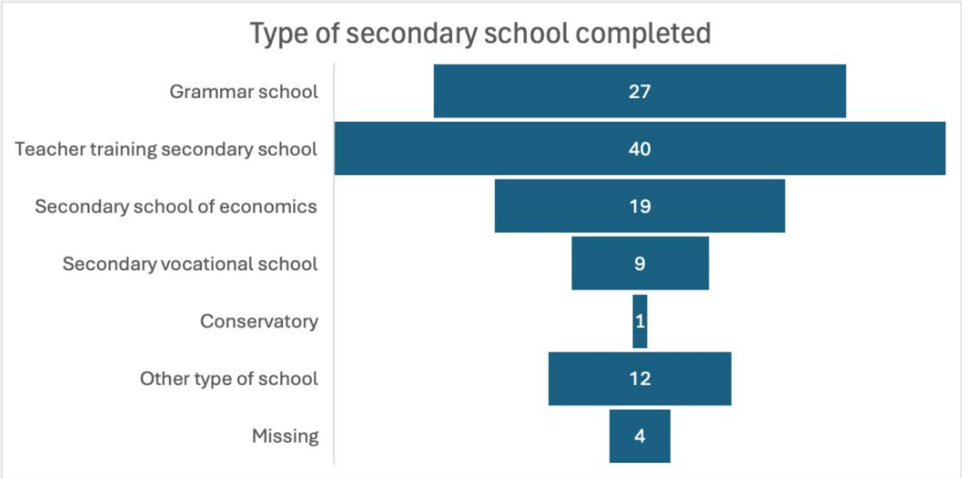

Figure 2. A chart showing the number of responses by school type

Control of the relationship between AI usage skills and attitudes toward podcasts with age taken into account: Since a relationship between age and AI usage skills (AI_SKILL) was demonstrated ($\rho = -0.288$), it was necessary to verify whether the relationship between AI usage skills and attitudes toward podcasts was not merely a consequence of the age structure of the sample. Therefore, the variables AI_SKILL and POD_LEARN were first regressed on age, residuals were subsequently derived from the regression models (AI_SKILL_resid, POD_LEARN_resid), and these residuals were then correlated using Pearson's correlation. The analysis revealed a statistically significant positive correlation between the residuals ($r = 0.267$; $p = 0.005$; $N = 108$).

Even after controlling for age, the relationship between AI usage skills and attitudes toward podcasts remains statistically significant. This supports the interpretation that the observed association likely represents a robust relationship between technological skills and preferences for digital learning tools, rather than merely a side effect of younger students being generally more technologically proficient.

5. Discussion

The results suggest the existence of three relatively independent domains: (a) Mathematical experience and attitudes toward mathematics, (b) Technological readiness around Artificial Intelligence, and (c) Preferences for digital learning formats. Each of these domains is linked to different mechanisms and brings distinct implications for the organization and methodology of instruction in the preparation of future teachers. At the same time, several commonly examined contextual characteristics (form of study, type of completed secondary school, experience working in education) did not explain differences in the examined indices within this sample.

In practice, this means that these formal categories cannot be relied upon as simple criteria for targeting support; more relevant are individual student characteristics, particularly their level of technological readiness.

The relationship between mathematics anxiety and attitudes toward mathematics confirms that the affective component of learning mathematics remains significant even at the level of higher education for future teachers. For some students, mathematics is an emotionally demanding domain, which may reduce self-confidence, influence motivation, and weaken willingness to engage in problem solving. From a didactic perspective, this supports approaches that reduce uncertainty, explicitly structure problem-solving procedures, and create a safe learning environment in which errors are perceived as a natural part of learning rather than a cause for concern. In designing an AI assistant, this implies orienting its use toward the learning process itself: step-by-step explanations, the possibility of alternative explanations, ongoing checks of understanding, and reinforcement through feedback, rather than the provision of ready-made solutions.

Importantly, in this research sample no direct relationships were found between mathematics-related indices (ANX_MATH, ATT_MATH) and AI-related indices (AI_OPEN, AI_SKILL). This suggests that technological openness or skills alone do not constitute factors that would automatically alter mathematical experience. AI therefore cannot be viewed as a universal tool for reducing mathematics anxiety; its potential contribution depends on the manner of its didactic integration and on whether AI support increases the sense of control over problem solving and fosters learner autonomy.

In the area of technological readiness, the findings showed that openness to AI integration and AI usage skills are related but do not represent identical constructs.

This differentiation has direct implications for educational practice: The development of AI literacy among future teachers should not remain at the level of declared attitudes but should include systematic support for practical skills. This primarily involves the ability to formulate appropriate prompts, verify and validate outputs, and critically reflect on the limitations of AI tools within the educational process. The fact that differences between AI users and non-users were manifested mainly in the technological domain further suggests that the quality and meaningfulness of technology use, rather than mere frequency, are decisive.

Another important finding is the relationship between AI usage skills and the acceptance of digital learning tools, specifically podcasts. This relationship persists even after controlling for age, indicating that it reflects a broader technological competence rather than a direct effect of AI use itself. From a didactic perspective, this supports an approach in which digital formats are offered as optional, differentiated support, complemented by parallel alternatives (e.g., text summaries, worksheets). Such a design reduces the risk that students with lower technological skills will be excluded from support, while at the same time allowing individual choice of learning format according to personal preferences.

A significant finding is the negative relationship between age and AI usage skills, pointing to differences in technological readiness even within a student population with diverse age composition. From the perspective of inclusive self-study support design, this suggests the need for differentiated "technological onboarding" that considers varying initial levels of experience with AI and reduces barriers when beginning to work with an AI assistant.

Implications for the implementation of a personalized AI assistant and AI-generated podcasts in instruction: A personalized AI assistant cannot be understood merely as a technological tool, but rather as a pedagogical instrument that (i) Responds sensitively to mathematical uncertainty, (ii) Supports the development of AI skills, and (iii) Enables flexible forms of learning tailored to students' preferences. When translating the findings into the implementation phase, three key principles emerge:

1. Didactic design of the assistant for students with mathematical uncertainty. The assistant should be configured as a "coach": step-by-step guidance, hints, process checking, a sensitive tone, and reinforcement of learner autonomy.
2. Onboarding as a prevention of deepening differences in technological readiness. Since AI users achieved higher levels of both AI_SKILL and AI_OPEN, implementation without accompanying support may lead to uneven effects: some students will fully benefit from the assistant, while others may remain excluded. A brief, explicit onboarding process and clearly defined minimum standards for working with AI therefore represent a key element of implementation.
3. Podcasts and other digital formats as optional, differentiated support. Attitudes toward podcasts do not differentiate AI users as such but rather differentiate students according to their level of AI skills. This implies the appropriateness of offering a variety of materials and allowing students to choose among them.

Comparison with expectations and possible explanations of the relative independence of domains. Intuitively, one might expect that students with higher mathematics anxiety or less favourable attitudes toward mathematics would either seek technological support more actively (and thus be more open to AI) or, conversely, reject technology. However, in the statistical sample, no direct relationships were found between mathematics-related indices (ANX_MATH, ATT_MATH) and AI-related indices (AI_OPEN, AI_SKILL), which supports the interpretation of their relative independence.

This result can be explained in several ways. First, mathematics anxiety is an effective response tied to a specific performance and evaluation domain (problem solving, testing, fear of failure), whereas openness to AI and AI usage skills may be more strongly conditioned by general technological self-confidence, experience with digital tools, and study habits. Second, students may perceive AI primarily as a pragmatic tool for obtaining information or rapid support, without expecting it to alter their relationship with mathematics; changes in mathematical experience may occur only through targeted, didactically guided integration. Third, the absence of a relationship may be related to the heterogeneity of anxiety-coping strategies: some students actively seek support when uncertain, while others display avoidance tendencies and do not use technology even when it could be beneficial. Pedagogically, this implies that an AI assistant will not automatically reduce mathematics anxiety; achieving this goal requires methodological guidance and integration with support for self-confidence and a sense of control over problem solving.

Implications for AI assistant design: functions and principles - The results support a differentiated design of an AI assistant that must respond sensitively to students' mathematical experience (anxiety, uncertainty) while also considering differing levels of technological readiness (AI_SKILL, AI_OPEN, experience with AI use). From these findings, several design principles emerge that are essential for meaningful and pedagogically grounded implementation.

1. **The assistant as a tutor focused on the problem-solving process rather than result generation.**
   The default mode of the assistant should promote understanding of procedures through step-by-step guidance, explanations of the rationale behind individual steps, control questions, and ongoing checks of understanding.
2. **Scaled support adapted to the learner's level.**
   Support should be provided progressively, ranging from hints about the next step, through partial explanations, to complete solutions, in a way that fosters autonomy while reducing frustration during learning.
3. **Built-in mechanisms for verification and control.**
   Since AI can generate imprecise or incorrect outputs, the assistant should systematically encourage result verification (e.g., back-substitution, estimation, unit checks), offer alternative solution approaches, and highlight common errors.
4. **Short onboarding and an accessible prompt library.**
   To minimize differences in technological readiness, it is advisable to include an introductory onboarding and provide access to a library of recommended questions and prompts (e.g., "explain the procedure," "check my step," "give me only a hint," "create a similar problem"), which facilitate meaningful interaction with the assistant.
5. **Integration with podcasts as an optional complement.**
   As preferences for podcasts are more closely related to AI skill level than to AI use itself, audio materials should be offered as optional support, always in combination with a text-based alternative.
6. **Ethical framework and support for academic integrity.**
   An essential component of the design is a clear delineation between legitimate AI use (hints, explanations, practice) and unacceptable substitution of independent problem solving. Accordingly, the assistant should be configured so that requests aimed at obtaining "ready-made solutions" are redirected confirmed with explanations, hints, or work on analogous problems rather than providing final answers directly.

6. Conclusion

The pre-test conducted at the beginning of the winter semester of the 2025/2026 academic year provided a methodologically grounded baseline framework for the planned implementation of a personalized AI assistant to support self-study in the university-level course Primary Mathematics Education – Arithmetic. The constructed indices made it possible to capture three key domains: mathematical experience and attitudes toward mathematics, technological readiness, and didactic preferences, and to identify their interrelationships relevant to the practical configuration of student support.

Three main empirical conclusions emerge from the study. First, mathematics anxiety and attitudes toward mathematics form a consistent relationship, with higher levels of mathematics anxiety associated with less positive attitudes toward mathematics. This finding highlights the importance of the affective–motivational dimension of learning mathematics even in the preparation of future teachers and indicates the need for didactic approaches that strengthen a sense of safety, predictability of problem-solving steps, and constructive handling of errors. Second, technological readiness emerged as a relatively independent domain. Openness to AI integration is related to AI usage skills, and both characteristics reach higher levels among students who actively use AI, pointing to differing initial levels of readiness within the study group. Third, a more positive attitude toward podcasts as a learning tool is associated with higher AI usage skills, and this relationship persists even after controlling for age, suggesting a broader link between technological competence and acceptance of digital forms of learning.

From an applied perspective, the results support three key recommendations for implementing an AI assistant in self-study. (1) Onboarding as a necessary entry component - a short, structured introductory support focused on basic principles of working with AI, formulating questions, using hints, and verifying answers is essential for reducing differences in technological readiness. (2) Differentiated support for students with lower AI skills—the use of simple question templates, step-by-step guides, and model dialogues can ensure that the AI assistant supports understanding of the problem-solving process and does not lead to passive adoption of ready-made solutions, which is also important in relation to mathematics anxiety. (3) Digital supplements as optional support - The combination of an AI assistant with short audio explanations or podcast segments appears particularly suitable for more technologically skilled students, while maintaining parallel alternatives (text summaries, worksheets) supports instructional inclusiveness.

The interpretation of the results must consider several methodological limitations. The data represent a pre-test from a single cohort and a single course, which limits the possibilities for generalization. At the same time, the reliability of the AI_OPEN index was lower ($\alpha = 0.626$), which is defensible in pedagogical research with a smaller number of items. A natural next step is to verify the construct validity of the created indices (e.g., through factor analysis) and to conduct a subsequent pre-test–post-test comparison after the actual implementation of the AI assistant. This approach will make it possible to assess whether the intervention contributes not only to the development of technological competence but also to changes in study strategies, attitudes toward mathematics, and potentially to a reduction in mathematics anxiety, which is crucial in the preparation of future primary education teachers.

Acknowledgements

The authors gratefully acknowledge the Grant Agency of the Faculty of Education of the Catholic University in Ruzomberok 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.

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