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Research Article

# Investigation of Music Teacher Candidates' Technology Integration Self-Efficacy and Artificial Intelligence Literacy

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**Abstract:**

The aim of this study is to examine the artificial intelligence (AI) literacy and technology integration self-efficacy of pre-service music teachers enrolled at various universities in Türkiye. The research employed a relational survey model, a quantitative research method. The sample consisted of 228 pre-service music teachers studying in music education departments. Data were collected using the Technology Integration Skills Scale and the Artificial Intelligence Literacy Scale.The findings revealed that participants had a high level of self-efficacy in technology integration. In terms of AI literacy, their scores were high in the awareness, evaluation, and ethics sub-dimensions, while a moderate level was observed in the usage sub-dimension. No significant differences were found between male and female participants in either variable. However, second-, third-, and fourth-year students demonstrated higher mean scores than first-year students in the 'computer use' sub-dimension of technology integration and the 'ethics' sub-dimension of AI literacy. No significant grade-level differences were observed in the remaining sub-dimensions or in overall scale scores.Based on these results, it is recommended that future studies adopt longitudinal and mixed-method approaches. Furthermore, teacher education programs are encouraged to revise their curricula to include course content that supports the development of competencies in technology integration and AI literacy.

**Keywords:** Music teaching, Pre-service teacher, Technology integration, Artificial intelligence literacy, Self-efficacy

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## INTRODUCTION

In the twenty-first century, technology integration has emerged as an essential component of teacher training programs. The innovations brought by technology facilitate both the diversification of teaching materials and the adoption of student-centered approaches. The Technopedagogical Content Knowledge (TPACK) model expresses the teacher's holistic use of pedagogical, content and technological knowledge. In this regard, technology integration requires not only the acquisition of technical skills but also the effective use of pedagogical and content knowledge (Koehler & Mishra, 2009). In terms of music education, technology plays a critical role in increasing student engagement and personalizing learning processes. Therefore, technology integration constitutes an essential dimension of contemporary music teacher education (Campanini, 2023).

The rapid diffusion of artificial intelligence (AI) technologies in education reinforces the need for teachers to make pedagogical sense of new digital tools. Laupichler et al. (2022) emphasize that AI literacy has become an interdisciplinary imperative in higher and adult education. Chiu et al. (2024) define AI literacy as the individual's ability to understand, critically evaluate and responsibly use artificial intelligence systems. The transformative role of technology in the context of music education is becoming more evident with the spread of learner-centered approaches, especially adaptive learning process and artificial intelligence-based feedback systems bring new perspectives in instructional design (Gall, 2017; Kibici & Sarıkaya, 2021). Teacher self-efficacy beliefs describe the perceptions of teachers or prospective teachers that they can successfully fulfill pedagogical tasks and predict their professional performance (Nyinge et al., 2024). Bandura's (1986) social cognitive theory suggests that self-efficacy belief is a fundamental variable that determines an individual's behaviors, efforts and performances. That’s is why the study aimed to examine the AI literacy and technology integration self-efficacy of music teacher candidates studying at different universities in Turkey in a relational way.

### Research Problem and Its Importance

Although technology integration courses are available in music teacher training programs in Turkey, it remains unclear to what extent these courses reflect the practical self-efficacy levels of teacher candidates. Sarıkaya (2022) and Gudek (2019) state that teacher candidates' computer self-efficacy is at a moderate level, but their self-confidence in using advanced music technology tools is limited. Atabek and Burak (2020) show that early childhood teacher candidates develop positive attitudes towards technology, but they lack knowledge about choosing technological tools in music teaching. AI-supported music applications offer new creative opportunities to teacher candidates, but the pedagogical basis of these applications is often neglected. Chiu et al. (2024) argue that programs aimed at developing AI literacy should be adapted on a discipline basis. The number of studies addressing AI literacy in the context of music education is limited, and existing studies are generally limited to discussions at the conceptual level. Therefore, empirically examining

the relationship between music teacher candidates' technology integration self-efficacy and AI literacy indicates an important research gap. Understanding this relationship can guide the restructuring of content and pedagogical strategies of teacher training programs. The fact that teacher candidates do not feel technologically competent negatively affects their desire to use new digital tools in their classes. This situation limits students' digital music literacy gains and prevents their learning experiences from being enriched. In addition, teacher candidates' uncertainties about AI literacy limit their potential to use AI-based assessment and feedback systems for pedagogical purposes.

Clarifying the relationship between technology integration self-efficacy and AI literacy allows program coordinators to reorganize course content in a holistic manner. These findings increase the functionality of technology laboratories offered to preservice teachers and increase the pedagogical effectiveness of hardware investments. When preservice teachers' self-efficacy levels increase, resistance to using technology in classroom practices tends to decrease, leading to greater adoption of innovative pedagogical strategies (Wang, Ertmer, & Newby, 2004; Banas & York, 2014). Preservice teachers with high AI literacy are more likely to use adaptive systems that support students' personalized learning paths, which in turn may lead to increased student motivation and improved learning outcomes (Chiu et al., 2024; Dai, 2021; Salas-Pilco et al., 2022). Teacher training institutions can use research results as quality indicators in program accreditation processes. Based on the findings, policy makers can systematically add technology integration and AI literacy components to national curriculum frameworks. Professional development programs in the field of music education can organize targeted workshops by referencing the relationship patterns revealed by the research. In this way, the effectiveness of in-service training activities increases and sustainable learning communities are created. From the perspective of students, technology and AI-enabled learning environments encourage creativity and strengthen critical listening skills. The research is also important in terms of reducing the digital divide, supporting equal access to learning opportunities for students from different socioeconomic backgrounds. In addition, the findings make visible the central role of technological competencies in the development of professional identity of prospective teachers. In the long term, technology and AI-literate music teachers can make innovative contributions in the areas of digital music production and consumption in the cultural life of society. Therefore, the research has a wide-ranging impact by guiding both classroom practices at the micro level and educational policies at the macro level.

In this respect, the research aimed to examine the relationship between artificial intelligence literacy and technology integration self-efficacy among music teacher candidates studying at different universities in Turkey. The following five questions were investigated in the research.

1) What are the levels of AI literacy and technology integration self-efficacy of music teacher candidates?

2) Do AI literacy and technology integration self-efficacy of music teacher candidates differ according to gender?

3) Do AI literacy and technology integration self-efficacy of music teacher candidates differ according to grade level?

4) Does the technology integration self-efficacy of music teacher candidates significantly predict their AI literacy?

## Theoretical Framework

### Technology Integration in Music Education

The significance of technology integration in music teacher training programs has been increasing over the last few decades, and themes such as digital literacy, pedagogical content knowledge, and artificial intelligence-supported learning environments have taken a central position within the scope of interdisciplinary approaches. When the evolution of technology integration in the literature from early studies to the present day is examined, it is seen that technology is not only a tool but also a transformative factor that is at the core of music pedagogy (Gudek, 2019). Bauer, Reese, and McAllister (2003) state that technology transforms teachers' teaching strategies and positively affects student motivation. The inclusion of AI-based tools in music education offers innovative possibilities such as personalized feedback, automated notation, and performance analytics in instructional design. This creates the need to redefine pre-service teachers' technology integration self-efficacy (Dai, 2021).

Technology integration in music teacher education requires strategic planning in a broad framework from program design to implementation. Dorfman (2016) points out that technology integration should be embedded in the core courses of the program, and in these cases, pre-service teachers' attitudes towards technology turn significantly positive. Bauer and Dammers (2016) found that when technology courses are integrated with pedagogical content courses instead of offering them as a separate module, pre-service teachers' ability to adapt technology to classroom practices is higher. At the same time, instructors' technology competency levels play a critical role in program outcomes (Haning, 2016). TPACK-based project courses provide pre-service teachers with the opportunity to apply theoretical knowledge in practice and reinforce their self-efficacy to develop innovative instructional designs (Tejada & Morel, 2019). Partti, Weber, and Rolle (2021) state that sustaining communities of learners through digital platforms supports professional learning after graduation. Greher's (2011) music technology partnership model reports that university-school collaboration increases candidates' professional confidence by providing authentic experiences of technology integration in real classroom contexts. Tobias (2017) argues that technological tools in music pedagogy, with the suggestion of repositioning technology, should be considered as pedagogical meaning-making elements rather than

purely instrumental, and this approach contributes to pre-service teachers' development of critical technological literacy. In this context, it is emphasized in the literature that theoretical and practical components should be integrated in a balanced way in curriculum design, and the interaction among the courses of field, pedagogy, and technology should be given importance.

The sustainability of technology integration varies depending on multi-layered factors such as infrastructure facilities, academic staff quality and institutional support policies. O'Leary and Bannerman's (2023) analysis of the pandemic process shows that the capacity of technical support units to respond quickly in the transition to online teaching directly affects pre-service teachers' motivation to use technology. Zelenak (2015) highlights that pre-service teachers' participation in applied workshops reinforces their technology integration skills and increases the level of classroom innovation. Bauer (2013) analyzes the TPACK acquisition process in detail and states that interdisciplinary project designs improve pre-service teachers' technology literacy and creative problem-solving skills. Haning (2016) states in his research that the attitudes of mentor teachers in practice schools towards technology are directly reflected in the classroom practices of pre-service teachers and shape their self-efficacy perceptions. Therefore, technology integration in music teacher education necessitates a sustainable and systemic approach, and the success of this approach is shaped by holistic policies and practices.

Bauer and Dammers (2016) argue that the vast majority of music teacher education programs in the US include compulsory courses on technology, which systematically strengthen preservice teachers' digital competencies. Haning (2016) shows that pre-service teachers' readiness to use technology varies from program to program, and these differences are associated with factors such as curriculum design, instructor quality, and infrastructure facilities. The integration of technology into music education is not only limited to technical skills, but also includes student-centered teaching, creativity-supported applications, and data-based feedback processes. In this respect, the project-based course model developed by Tejada and Morel (2019) based on the TPACK framework allows prospective music teachers to construct pedagogical and technological knowledge simultaneously and reveals the importance of application-oriented learning experiences. The rapid spread of distance and hybrid teaching models during the pandemic period makes the requirements for technology integration even more visible; according to the findings of O'Leary and Bannerman (2023), the integration of online platforms into creative music production processes has become inevitable. Walls (2008) indicates that distance graduate music teaching experiences expand access to professional development by overcoming geographical barriers and encourages technology-enhanced instructional design. Thus, technology integration is not only embedded in course content but becomes part of institutional culture and professional learning communities.

### Self-Efficacy in Technology Integration

Technology integration self-efficacy refers to music teacher candidates' beliefs and perceptions of competence in using digital tools for pedagogical purposes, and is accepted as one of the main determinants of learning motivation within the framework of Bandura's (1986) social cognitive theory. According to Bandura (1986), self-efficacy affects individuals' decisions to take action, their level of effort, their persistence in the face of difficulties and their emotional reactions. In the field of educational sciences, self-efficacy is examined in various dimensions such as teachers' classroom management, instructional design, and technology integration. It is reported that high self-efficacy perception is positively related to openness to innovative practices and professional satisfaction. A high self-efficacy perception reinforces pre-service teachers' tendencies to engage in innovative practices, cope with challenges, and set long-term professional development goals.

Wagoner (2015) reveals that there is a strong correlation between self-efficacy and professional commitment in terms of music teacher identity, and this finding emphasizes the role of self-efficacy in the construction of professional identity. Kılıç (2015) discusses the relationship between computer anxiety and self-efficacy and shows that teachers with low self-efficacy perception have high levels of anxiety towards technology, and this situation negatively affects integration efforts. Wang, Ertmer, and Newby's (2004) experimental study indicates that modeling and successful experiences increase self-efficacy, which is reflected in technology integration behavior. Banas and York (2014) examine the effect of authentic learning activities on self-efficacy and state that instructional design supported by authentic tasks reinforces preservice teachers' confidence in technology integration. Wang, Ertmer, and Newby (2004) state that pre-service teachers with high levels of self-efficacy for technology integration adopt more creative and student-centered methods in classroom practices. Sarıkaya's (2022) research on music teachers reports that technology integration self-efficacy shows significant relationships with the frequency of individual technology use and perceived infrastructure support. Gudek's (2019) computer self-efficacy study shows that music teacher candidates' attitudes towards digital technology affect their self-efficacy level and that these attitudes develop positively during the program. Doherty's (2021) research findings show that self-efficacy perceptions are strengthened and behavioral intention towards technology integration increases when content, pedagogical, and technological knowledge are taught in an integrated manner. Gomez et al. (2022) measured self-efficacy within the framework of ISTE standards and indicate that standards-based practices increase preservice teachers' digital pedagogical awareness and confidence levels. Thus, the concept of self-efficacy is a critical motivational element in pre-service teachers' professional learning processes and serves as a strategic lever in the context of technology integration (Kibici, 2022).

Longitudinal studies examining how self-efficacy perceptions change over the course of the program show that factors such as frequency of exposure to technology, depth of practice,

and quality of feedback are decisive. Zelenak (2015) reported that workshop-based interventions had lasting effects on self-efficacy growth and that candidates maintained positive attitudes towards technology use even after graduation. In addition, infrastructure inadequacies and limited technology access negatively affect the development of self-efficacy perception, highlighting the importance of institutional support policies (Sarıkaya, 2022). Wang, Ertmer, and Newby (2004) state that learning through modeling is especially effective in candidates with low initial self-efficacy levels, and increases the sense of confidence. Thus, technology integration self-efficacy, as a dynamic construct, is shaped by the interaction of program design, learning experiences, and environmental conditions. In the literature, the factors affecting pre-service music teachers' technology integration self-efficacy beliefs are discussed in individual, programmatic, and environmental dimensions. Wang, Ertmer, and Newby (2004) state that direct experience and success stories have strong effects on self-efficacy, while Banas and York (2014) state that authentic learning activities reinforce this effect. Among the environmental factors, institutional culture, policy support, and technological infrastructure indirectly affect self-efficacy beliefs and direct the integration behaviors of pre-service teachers. O'Leary and Bannerman (2023) explain that the ability of universities to provide rapid technical support in the online teaching process positively affects the attitudes of candidates towards technology and accelerates the increase in self-efficacy. Zelenak (2015) reports that continuous support and peer collaboration in professional development programs strengthen the perception of self-efficacy and increase the frequency of technology use. In addition, the attitudes of pre-service teachers towards technology are related to the amount of time and resources allocated to technology integration in the curriculum (Atabek and Burak, 2020). Haning (2016) highlights that in cases where the technology infrastructure in practice schools is inadequate, candidates' perception of self-efficacy may be negatively affected and integration efforts may be limited.

### Artificial Intelligence Literacy in Teacher Education

Artificial intelligence (AI) literacy has emerged as a critical competency in contemporary teacher education, driven by the increasing integration of intelligent systems in educational contexts. This literacy encompasses not only technical understanding but also the ability to critically evaluate and ethically use AI tools in pedagogical settings.

The concept of artificial intelligence aims to bring human-like cognitive processes to the digital environment by encompassing subfields such as machine learning, deep learning and natural language processing (Smith, 2013; Miranda, 2021; Dai, 2021). In the context of educational sciences, artificial intelligence is transforming instructional design with innovative applications such as learning analytics, adaptive instructional systems, and automatic feedback mechanisms (Salas-Pilcove et al., 2022). In the field of teacher education, artificial intelligence literacy refers to the capacity of candidates to use these technologies effectively, ethically, and creatively for pedagogical purposes. This capacity includes the dimensions of technical knowledge, critical evaluation, and ethical responsibility in a

holistic way (Weivd., 2022). While existing studies mostly focus on general teacher education, the specific role of AI literacy in music education remains underexplored. Given the creative and performative nature of music teaching, it is crucial to investigate how future music teachers engage with AI technologies in ways that support both artistic expression and instructional design.

It is emphasized in the literature that interdisciplinary learning experiences play a critical role in the development of artificial intelligence literacy (Weive et al., 2022). The basic understanding by pre-service teachers of how artificial intelligence algorithms work facilitates the adaptation of these algorithms to classroom applications. In addition, the ability to transparently question the decision mechanisms of artificial intelligence-based tools strengthens the critical thinking competencies of the candidates (Gomez et al., 2022). In terms of ethics, the issues of data privacy and algorithmic bias are discussed in the teacher education curriculum to increase the candidates' awareness. International standards on artificial intelligence literacy provide reference frameworks for measuring and developing the competencies of pre-service teachers. These frameworks suggest comprehensive gains that include cognitive, affective and psychomotor goals (Chiu et al., 2024). For music teacher candidates, these ethical and critical competencies are particularly important when using AI tools that analyze student performances, collect audio-visual data, or provide automated feedback. Evaluating the transparency and fairness of such tools requires a solid understanding of both musical content and ethical considerations, ensuring that technological decisions do not override pedagogical values.

Research shows that programs that support artificial intelligence literacy also increase the technology integration self-efficacy of pre-service teachers. This increase paves the way for candidates to use artificial intelligence tools more boldly and creatively in classroom applications. Therefore, the conceptualization of artificial intelligence in the context of teacher education addresses pedagogical, technical, and ethical dimensions with a holistic approach. This holistic approach improves the skills of prospective teachers required to solve complex problems of the digital age. Accordingly, artificial intelligence literacy plays a decisive role in the future of teacher education. This role both increases student success and strengthens the professional identities of teachers (Dai, 2021). In the context of music teacher education, this means empowering candidates not only to use AI for technical tasks such as notation or performance tracking, but also to make informed pedagogical choices aligned with their musical and educational goals. As AI continues to influence the creative arts, equipping music educators with both confidence and critical awareness will be key to ensuring that technology enhances, rather than diminishes, musical learning and expression.

## Artificial Intelligence and Music Education: Current Trends and Gaps

While AI literacy is gaining momentum in general teacher education, its role in music education is only beginning to be explored. Given the unique nature of music instruction—

blending creativity, performance, and pedagogy—artificial intelligence holds transformative potential but also presents distinct challenges. This section reviews current trends in AI applications in music teacher training and identifies key gaps in the literature.

The increasing use of technology in music teacher training programs brings new perspectives and methods to the education process. The rapid development of technology requires the inclusion of AI applications in the professional skill set and areas of interest of teacher candidates. Since music education is a field where theoretical knowledge and practice are intertwined, and creative processes are at the forefront, the concept of artificial intelligence literacy becomes increasingly important. AI literacy requires teacher candidates to understand not only the skills to use technology, but also the ethical, pedagogical, and practical innovations brought by this technology. It is especially important for music teacher candidates to be familiar with many dimensions of technology, from classroom management to measurement and evaluation, as well as its creative potential (Dorfman, 2016; Bauer & Dammers, 2016). However, despite this potential, few studies have addressed how AI literacy specifically supports pedagogical and artistic goals in music education. This gap highlights the need for further empirical investigation into how pre-service music teachers develop and apply AI-related competencies within their field.

Thanks to AI-based applications, prospective teachers can design materials for different learning styles and create music education environments customized to students' interests (Laupichler et al., 2022). At the same time, the feedback provided by AI-supported systems to prospective teachers also provides a continuous transformation cycle in their professional development. Therefore, artificial intelligence literacy is seen as a critical competence that future teachers in the field of music education should have. Understanding the pedagogical infrastructure of artificial intelligence technologies used in music lessons and the effective use of these technologies positively affects students' musical creativity and academic success. In addition, these technologies offer useful solutions in distance education processes. O'Leary and Bannerman (2023) state that the importance of technological tools and artificial intelligence-supported platforms in education has increased even more during the COVID-19 pandemic. In the context of music education, AI tools such as intelligent accompaniment generators, automated notation platforms, and real-time performance analysis systems offer powerful means to enhance creativity and motivation. These tools can help pre-service music teachers create more engaging, personalized, and data-informed instructional strategies. Thus, prospective music teachers need to develop both technology integration self-efficacy and artificial intelligence literacy in order to adapt to these changing educational dynamics. On the other hand, the ethical and security dimensions of artificial intelligence literacy should not be ignored. The data collection and analysis processes of various applications bring the principles of protection of students' personal data and ethical use to the forefront (Su et al., 2023).

Interdisciplinary projects produce innovative solutions by integrating the fields of music, computer science, and educational technology. These projects strengthen the creative thinking and problem-solving skills of teacher candidates. Collaborative learning environments facilitate the sharing of the candidates' experience and knowledge and support peer learning (Partti et al., 2021). In the evaluation processes, candidates' AI literacy competencies are measured using performance-based criteria and reflective portfolios. These measurement tools monitor candidates' learning processes and support the development of their self-regulation skills. The programs reinforce candidates' strengths with continuous feedback mechanisms and provide support for development areas (Han et al., 2025). For pre-service music teachers, these interdisciplinary approaches can foster not only technical fluency but also artistic experimentation—helping them design lesson plans that merge AI tools with musical creativity. In the context of music teacher education, AI literacy enables pedagogical innovations in areas such as composition, performance analytics, and musical data visualization. AI-supported composition software allows students to quickly put their creative ideas into notation and receive instant auditory feedback (Smith, 2013). Performance analytics tools provide personalized feedback to students by monitoring parameters such as rhythm accuracy, intonation, and dynamic control in real time (Dai, 2021). These tools, when critically and creatively used by teacher candidates, can transform traditional assessment models and support more individualized music instruction. The artificial intelligence literacy of music teacher candidates encourages a culture of data-based decision-making in course design processes. Visualization of student performance data allows teacher candidates to quickly identify learning gaps (Bauer, 2013). This detection provides an opportunity to individualize and differentiate teaching strategies. In addition, automatic assessment tools supported by artificial intelligence improve teacher candidates' time management (Han et al., 2025). This detection provides an opportunity to individualize and differentiate teaching strategies. In addition, automatic assessment tools supported by artificial intelligence improve teacher candidates' time management (Han et al., 2025).

Cui's (2023) augmented reality-based piano teaching application increases students' learning motivation and accelerates technical skill acquisition through multi-sensory feedback mechanisms. These innovative applications provide different perspectives on teacher candidates' pedagogical design competencies, improve their ability to interpret learning analytics data, and dynamically adapt the course flow. Yao and Li (2023) conducted a study on online music learning environments and emphasized that technological tools can support learning outcomes even in scenarios without teachers; however, teacher guidance is indispensable for pedagogical integrity. For music teacher candidates, these examples highlight the importance of developing both the technical ability to use such tools and the pedagogical judgment to apply them meaningfully. Without critical training, candidates may adopt AI tools without fully considering their alignment with instructional goals or the needs of diverse learners. Thus, the role of technology is not only instrumental, but also

stands out as a factor that shapes learning communities and redefines student-teacher interaction. In the constantly updated digital ecosystem, the ability of prospective teachers to make critical choices and ensure appropriate means-purpose alignment is of strategic importance. As stated by Haning (2016), pedagogical beliefs towards technology are one of the fundamental variables that determine the quality of integration; and learning experiences that support these beliefs should be included in program design. In addition, the impact of cultural context and school infrastructure on technology use cannot be ignored, and different socioeconomic conditions require integration strategies to be flexible and context-sensitive. In this regard, music teacher education programs must ensure that candidates not only learn how to operate AI-enhanced tools, but also how to evaluate their relevance, fairness, and artistic value in the context of music learning.

## METHOD

In the study, the relational screening model, one of the quantitative research methods, was used, and the survey technique served as a measurement tool. In the relational screening method, it is determined whether there is a change among two or more research variables that may increase or decrease together (Piwowarski, 2001). Based on this method, the research will examine the relationships between the self-efficacy for technology integration and the literacy in artificial intelligence of the teacher candidates studying in the music teaching department of universities in Turkey. In this context, it aims to examine the relationship between demographic variables such as gender and class.

### Participants

The population of the research consists of music teacher candidates studying in the education faculties of Turkish universities. Due to time, cost, accessibility, etc., constraints of reaching the overall population, the sample was formed from teacher candidates studying in music teaching departments of five universities. In this regard, the convenience sampling method, which is one of the non-random sampling methods, was employed. According to Emerson (2015), the sampling method is important to generalize and strengthen the representativeness of the sample regarding the population and the research results. As one of the non-probability sampling techniques, the convenience sampling method selects participants from the target population, according to the ease of access. For this purpose, the study was conducted with 228 participants based on convenience sampling. 149 of the participating music teacher candidates were female, and 79 were male. In addition, 67 of the participating music teacher candidates were in the first year, 38 in the second year, 70 in the third year, and 53 in the fourth year.

### Data Collection Tools

'Technology Integration Skills Scale' and 'Artificial Intelligence Literacy Scale' were used as data collection tools in the study.

*Technology Integration Self-Efficacy Perceptions Scale*

In order to determine the technology integration self-efficacy perceptions of music teacher candidates, the "Technology Integration Self-efficacy Perception Scale" developed by Wang et al. (2004) and adapted to Turkish by Ünal (2013) will be used. The scale, which was prepared in the form of a five-point Likert type, has two dimensions as "Self-efficacy in Using Computer Technologies" and "Self-efficacy in Using Computer Technologies" and consists of 19 items. The scale allows for scores ranging from a minimum of 19 points to a maximum of 95 points. The Cronbach alpha coefficient for the reliability of the technology integration self-efficacy perception scale was calculated by Ünal (2013) as 0.94 and as 0.95 as a result of the reliability analysis conducted in this study.

*Artificial Intelligence Literacy Scale*

To assess AI literacy in a valid and reliable manner, a Likert-form measurement tool developed by Wang et al. (2022) and standardized for Turkish by Çelebi et al. (2023) was used. The scale, consisting of a total of 12 questions, has a five-point response form. Exploratory and confirmatory factor analyses conducted by Çelebi et al. (2023) show that the scale has strong construct validity consisting of four sub-dimensions. There are three questions in each sub-dimension of the AI literacy scale. In this respect, the AI literacy scale is easy to use. The Cronbach Alpha reliability coefficient for the sub-dimensions of the AI literacy scale varies between 0.77 and 0.85. The test reliability, including all items on the AI literacy scale, was calculated as 0.85.

## Data Analysis

Before the analysis of the quantitative data obtained within the scope of the research, whether the data obtained meet the assumptions of parametric tests was tested. Based on the analysis results, it was determined that the scores obtained from the Technology Integration Self-Efficacy and Artificial Intelligence (AI) Literacy Scales met the assumptions of parametric statistics, and the differentiation status of the data obtained from this scale according to the gender variable was tested with independent sample t-Test analysis. Additionally, one-way ANOVA was used in the comparison according to the class level. In order to determine the source of the difference in the group differences detected as a result of ANOVA, the Scheffé test from post hoc tests was used. Multiple regression analysis was used to examine the technology integration self-efficacy and artificial intelligence (AI) literacy of music teacher candidates and to test the relationships between these variables. The data obtained for statistical analysis were evaluated using the SPSS 27.00 program.

## FINDINGS

**Table 1.**

*Descriptive Analyses of Prospective Music Teachers' Technology Integration Self-Efficacy*

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Using the Computer** | 228 | 1,00 | 5,00 | 3,45 | 0,89 |
| **Letting Someone Else Use the Computer** | 228 | 1,00 | 5,00 | 3,55 | 0,89 |
| **Technology Integration** | 228 | 1,00 | 5,00 | 3,50 | 0,86 |

When Table 1 is examined, the mean scores of the sub-dimensions of the technology integration self-efficacy scale were calculated as 3.45 (SD=0.89), 3.55 (SD=0.89), and 3.50 (SD=0.86) for the entire scale. According to the mean scores, the results indicated that the technology integration self-efficacy of the music teacher candidates participating in the study was at a high level.

**Table 2.**

*Descriptive Analyses on Artificial Intelligence Literacy of Music Teacher Candidates*

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Awareness** | 228 | 2,00 | 5,00 | 3,53 | 0,61 |
| **Use** | 228 | 1,00 | 5,00 | 3,39 | 0,91 |
| **Evaluation** | 228 | 1,00 | 5,00 | 3,67 | 0,88 |
| **Ethics** | 228 | 1,67 | 5,00 | 3,61 | 0,73 |
| **AI Literacy** | 228 | 1,40 | 5,00 | 3,55 | 0,64 |

Upon examining Table 2, the mean scores of the sub-dimensions of the Artificial Intelligence Literacy Scale were found to be 3.53 (SD = 0.61) for the awareness sub-dimension, 3.39 (SD = 0.91) for the usage sub-dimension, 3.67 (SD = 0.88) for the evaluation sub-dimension, and 3.61 (SD = 0.73) for the ethics sub-dimension. The overall mean score for the scale was calculated as 3.55 (SD = 0.64). Based on these results, it can be concluded that the music teacher candidates who participated in the

study demonstrated a moderate level of competence in the usage sub-dimension and high levels in the other sub-dimensions as well as in overall artificial intelligence literacy.

**Table 3.**

*Comparison of Technology Integration Self-Efficacy of Prospective Music Teachers According to Gender*

| | Gender | N | Mean | Std. Deviation | t | p |
|---|---|---|---|---|---|---|
| **Using the Computer** | Female | 149 | 3,38 | 0,82 | 0,510 | 0,611 |
| | Male | 79 | 3,58 | 1,01 | | |
| **Letting Someone Else Use the Computer** | Female | 149 | 3,52 | 0,85 | -1,642 | 0,102 |
| | Male | 79 | 3,63 | 0,95 | | |
| **Technology Integration** | Female | 149 | 3,45 | 0,80 | -0,885 | 0,377 |
| | Male | 79 | 3,60 | 0,95 | | |

Table 3 presents the comparative results of the technology integration self-efficacy scale scores of music teacher candidates according to gender. According to the unrelated sample t-test analysis, the mean scores calculated on the whole technology self-efficacy scale and its sub-dimensions did not show any significant difference based on the gender variable ($p>0.05$).

**Table 4.**

*Comparison of Artificial Intelligence Literacy of Music Teacher Candidates Based on Gender*

| | Gender | N | Mean | Std. Deviation | t | p |
|---|---|---|---|---|---|---|
| **Awareness** | Female | 149 | 3,49 | 0,59 | -1,313 | 0,191 |
| | Male | 79 | 3,60 | 0,63 | | |
| **Use** | Female | 149 | 3,39 | 0,86 | -1,400 | 0,163 |
| | Male | 79 | 3,59 | 0,99 | | |
| **Evaluation** | Female | 149 | 3,65 | 0,87 | -1,585 | 0,114 |
| | Male | 79 | 3,70 | 0,89 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Ethics** | Female | 149 | 3,64 | 0,72 | -0,441 | 0,660 |
| | Male | 79 | 3,56 | 0,74 | | |
| **AI Literacy** | Female | 149 | 3,52 | 0,60 | 0,729 | 0,467 |
| | Male | 79 | 3,61 | 0,72 | | |

Table 4 indicates the results of comparing the AI literacy scale scores of music teacher candidates according to gender. According to the unrelated sample t-test analysis, the mean scores calculated on the entire AI literacy scale and its sub-dimensions did not show any significant difference based on the gender variable ($p>0.05$).

**Table 5.**

*Comparison of Technology Integration Self-Efficacy of Prospective Music Teachers According to Grade Level*

| | **Class** | **N** | **Mean** | **Std. Deviation** | **F** | **Sig.** |
|---|---|---|---|---|---|---|
| **Using the Computer** | 1 | 67 | 3,40 | 0,83 | 1,782 | 0,152 |
| | 2 | 38 | 3,36 | 1,07 | | |
| | 3 | 70 | 3,37 | 0,93 | | |
| | 4 | 53 | 3,69 | 0,73 | | |
| **Letting Someone Else Use the Computer** | 1 | 67 | 3,37 | 0,89 | 2,838 | 0,039 |
| | 2 | 38 | 3,51 | 1,00 | | |
| | 3 | 70 | 3,55 | 0,85 | | |
| | 4 | 53 | 3,83 | 0,80 | | |
| **Technology Integration** | 1 | 67 | 3,47 | 0,83 | 2,366 | 0,072 |
| | 2 | 38 | 3,43 | 1,01 | | |
| | 3 | 70 | 3,37 | 0,86 | | |
| | 4 | 53 | 3,76 | 0,73 | | |

Table 5 shows the comparison results of the self-efficacy scale scores for technology integration of music teacher candidates by grade level. According to the F test analyses, the mean scores calculated on the 'using the computer' subscale did not show a significant difference according to the grade level variable ($p>0.05$). According to further analyses, the participants studying in the second, third, and fourth grades had more advanced 'using the computer' skills compared to the participants in the first grade. However, no significant difference was found in the other dimension, and in the total, of the technology integration self-efficacy scale according to the grade level.

**Table 6.**

*Comparison of Artificial Intelligence Literacy of Music Teacher Candidates According to Grade Level*

| | Class | N | Mean | Std. Devition | F | p |
|---|---|---|---|---|---|---|
| **Awareness** | 1 | 67 | 3,35 | 0,57 | 3,337 | 0,020 |
| | 2 | 38 | 3,57 | 0,68 | | |
| | 3 | 70 | 3,56 | 0,62 | | |
| | 4 | 53 | 3,72 | 0,53 | | |
| **Use** | 1 | 67 | 3,41 | 0,84 | 1,895 | 0,131 |
| | 2 | 38 | 3,36 | 1,06 | | |
| | 3 | 70 | 3,37 | 0,94 | | |
| | 4 | 53 | 3,72 | 0,79 | | |
| **Evaluation** | 1 | 67 | 3,55 | 0,92 | 1,849 | 0,139 |
| | 2 | 38 | 3,85 | 0,89 | | |
| | 3 | 70 | 3,56 | 0,90 | | |
| | 4 | 53 | 3,82 | 0,75 | | |
| **Ethics** | 1 | 67 | 3,46 | 0,66 | 3,037 | 0,030 |
| | 2 | 38 | 3,52 | 0,84 | | |
| | 3 | 70 | 3,77 | 0,73 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 53 | 3,79 | 0,69 | | |
| **AI Literacy** | 1 | 67 | 3,45 | 0,62 | 2,471 | 0,063 |
| | 2 | 38 | 3,63 | 0,74 | | |
| | 3 | 70 | 3,48 | 0,66 | | |
| | 4 | 53 | 3,73 | 0,54 | | |

Table 6 presents the results of comparing the Artificial Intelligence (AI) literacy scores of music teacher candidates across different grade levels. According to the F-test analysis, significant differences were found in the 'awareness' and 'ethics' sub-dimensions based on grade level ($p < 0.05$). Post hoc analysis revealed that participants in the second, third, and fourth years had higher levels of awareness and ethical understanding related to AI literacy compared to first-year participants. However, no significant differences were observed in the 'use', 'evaluation' sub-dimensions, or in the overall AI literacy scores based on grade level ($p > 0.05$).

**Table 7.**

*Results of Regression Analysis to Determine the Prediction Level of Technology Integration Self-Efficacy on Artificial Intelligence Literacy*

| | **Unstandardized Coefficients** | | **Standardized Coefficients** | | |
|---|---|---|---|---|---|
| | **B** | **Std. Error** | **B** | **T** | **Sig.** |
| (Constant) | 1,150 | 0,073 | | 15,681 | 0,000 |
| **Technology Integration** | 0,686 | 0,020 | 0,913 | 33,716 | 0,000 |

Dependent Variable: AI Literacy, R=0,913; R2=0,833; F=1136,786; p<0,05

Table 7 shows the results of the regression analysis conducted to determine the relationship between the technology integration self-efficacy of music teacher candidates and their artificial intelligence literacy. According to the analysis, it is understood that technology integration self-efficacy is an effective factor in the artificial intelligence literacy of the participating music teacher candidates ($\beta$=0.686, $p<0.05$). In addition, technology integration self-efficacy explains 83.3% of

artificial intelligence literacy. In this respect, the technology integration self-efficacy of music teacher candidates affects their artificial intelligence literacy positively and significantly.

## DISCUSSION

The main purpose of this study is to reveal the capacity of teacher candidates to integrate technology into their pedagogical processes to meet the requirements of the digital age, and their competence in using artificial intelligence tools responsibly. According to the findings regarding the first research question of the study, the candidates' levels were generally high in these structures. This situation indicates that the candidates are willing to interact with digital pedagogical environments and have a strong belief in using technology effectively in teaching processes. The technology integration self-efficacy of the candidates overlaps with their skills in planning, implementing, and evaluating the use of digital tools. Artificial intelligence literacy supports the ability to comprehend the ethical, pedagogical, and practical dimensions of technology. The findings obtained show that the candidates see themselves as both competent in mastering technological tools and having positive expectations about integrating innovative technologies into classroom practices. The high level of competence perception suggests that the teacher candidates have acquired the necessary digital skills before starting their profession. The candidates' high levels of self-efficacy and AI literacy suggest that they perceive themselves as capable of utilizing digital technologies in course planning, and promoting student interaction. While the present study did not investigate the specific training experiences contributing to these perceptions, prior research highlights the role of professional development programs and practical coursework in shaping technology-related competencies (Wang et al., 2004; Haning, 2016; Tejada & Morel, 2019).

These findings are partially consistent with the views prominent in the existing literature. Studies indicate that music teacher candidates have high technology integration self-efficacy and artificial intelligence literacy levels The studies argue that this situation is supported by educational programs (Sarıkaya, 2022; Haning, 2016). In particular, studies emphasizing the role of technology integration in education indicate that candidates' skills in using digital tools for pedagogical purposes are reinforced through practical training processes (Tejada & Morel, 2019). It has been suggested in the literature that technology integration self-efficacy helps in adopting innovative pedagogical strategies in classroom practices (Bauer & Dammers, 2016). Similarly, studies on artificial intelligence literacy reveal that this competence supports candidates in using technology critically and creatively. Comparatively, the high level of perception obtained in our study is consistent with previous studies and shows that candidates' competence in adapting to technological developments is sufficiently supported. However, although some literature reports that

lower levels of perception are also observed among candidates, this difference varies depending on the training methods applied and sample characteristics (Gudek, 2019).

Within the scope of the second research question, the findings showed that the candidates had similar levels of self-efficacy and literacy perception based on gender. This suggests that male and female candidates exhibited a similar approach to interacting with digital technologies. It is understood that gender is not a determining factor in the development of technology use skills during the education process, and both groups benefit from similar support mechanisms. This equality may be because music teacher candidates have similar access to technological information and application opportunities within the scope of their education programs. The obtained results indicate that there are no gender-based differences, which are consistent with findings that gender effects are weak in some studies. Previous studies reported that gender differences are not evident in music teacher candidates' technology use skills and that both genders have similar learning experiences (Gudek, 2019; Atabek & Burak, 2020). This situation can be attributed to the implementation of common course contents, technological infrastructure, and teaching strategies in education regardless of gender.

The findings within the scope of the third research question show that senior candidates exhibit higher levels of performance, especially in subscales such as computer usage skills. This can be interpreted as the development of candidates' effective use of technology skills, with increasing experience and practical learning opportunities during the education process. Developing candidates according to their grade level, emphasizes the importance of gaining experience in putting theoretical knowledge into practice. In addition, with the increase in grade level, some significant differences emerged in artificial intelligence awareness and ethical behaviors. These results may reflect the cumulative impact of applied learning opportunities embedded in later stages of teacher education programs, such as project-based technology integration courses, practicum experiences with digital tools, and collaborative design of instructional materials (Tejada & Morel, 2019; Haning, 2016). Rather than suggesting that any curriculum would automatically lead to increased self-efficacy, these findings underscore the importance of structured, hands-on experiences and scaffolded exposure to educational technologies. Programs that integrate such components have been shown to foster not only technical proficiency but also confidence and openness toward innovative pedagogies (Bauer & Dammers, 2016; Wang et al., 2004). In the literature, the views that technological knowledge and practical skills increase as the education process progresses are supported, and this progression plays an important role in the professional development of candidates (Wang, Ertmer & Newby, 2004). The increase observed in sub-dimensions such as awareness and ethics in artificial intelligence literacy shows that comprehensive digital learning approaches implemented in education programs shape the attitudes of candidates positively. These findings are parallel to the literature supporting the idea that candidates gain more experience as the class

progresses, and that these experiences are reflected in their ability to use technology. Previous studies have stated that the participation of teacher candidates in applied training and mentoring programs accelerates the development of digital skills (Han et al., 2025).

The findings obtained in the study on whether the technology integration self-efficacy of music teacher candidates significantly explains artificial intelligence literacy showed that it has a strong and positive effect on artificial intelligence literacy. This finding suggests that the self-efficacy beliefs of the candidates regarding digital pedagogical applications increase their ability to use technology more effectively. The confidence of the candidates in using technology facilitates their adoption of the ethical, cognitive, and practical aspects of artificial intelligence tools. The high explanatory rate obtained underlines the interdependent relationship between digital competencies. This situation shows that the experiences of the teacher candidates regarding technology integration competencies during the education process are a determining factor in the development of artificial intelligence literacy. As the candidates are more exposed to technology-focused educational applications, they have also started to exhibit a more conscious and critical stance in using artificial intelligence. This finding reveals that technological skills are systematically integrated in the professional development processes of the candidates in accordance with the holistic application model of technology in education. In the literature, it has been suggested that technology integration self-efficacy supports pre-service teachers in using digital tools more effectively, and thus artificial intelligence-based applications can be implemented more successfully (Wang, Ertmer & Newby, 2004; Doherty, 2021). This shows that candidates' exposure to technology-focused applications enables them to use artificial intelligence technologies more consciously. Comparative analyses have revealed that this relationship is supported by interventions made within the scope of education programs and that candidates' digital competencies are complementary elements. In the literature, it is emphasized that technology integration increases the professional competencies of pre-service teachers and that artificial intelligence literacy is an important building block in the development of innovative pedagogical applications in education (Tejada & Morel, 2019). The findings show that these two structures positively affect each other in the development of candidates' digital pedagogical identities.

## Limitations of the Study

There are some limitations to consider when interpreting the findings of this study. The sample used in the study was limited to data obtained from only five universities; this may constitute a restrictive factor in interpreting the general validity. In addition, the data collection tool was implemented via a survey method brings with it the risk of subjectivity based on self-assessment. Although the measurement tool was adapted to the cultural context, there may be limitations as to whether it fully reflects the experiences of candidates from different geographical regions. In addition, the quantitative method used in the study

may have been limited in revealing the in-depth individual experiences and perceptions of the candidates.

## Conclusion and Recommendations

As a result, the research findings reveal a strong and positive relationship between the technology integration self-efficacy and artificial intelligence literacy, of music teacher candidates, providing an important theoretical and practical basis for the development of professional competencies required by the digital age. The high levels of self-efficacy and literacy perceptions obtained in the study supported the candidates' competencies in using digital tools, both technically and ethically, and this situation was parallel to similar findings in the existing literature. The data clearly obtained demonstrate that systematic support of technological competencies and their reinforcement with practical experiences play a decisive role in strengthening the professional identities of future teachers. In addition, the absence of gender differences in the study shows that egalitarian approaches in education can be successfully implemented. The development observed at the class level emphasizes that candidates' digital competencies will increase as they gain experience in the education process. Regression analyses revealed that technology integration self-efficacy is a critical determinant in explaining artificial intelligence literacy, proving that the two aspects are complementary processes. These results provide significant contributions, both theoretically and practically, to the development of current approaches to digital transformation strategies for teacher education programs.

Future studies should use larger samples to overcome the methodological limitations of this study. Generalizations should be made with data obtained from different universities. Longitudinal and mixed method approaches are valuable in terms of revealing the changes in digital competencies of teacher candidates over time, in detail. Supporting studies with qualitative methods to examine candidates' individual experiences in depth will provide richer data on technology integration and artificial intelligence literacy. In addition, examining the effects of support mechanisms and internship programs used in the pedagogical implementation process will make significant contributions to interpreting the obtained data. In future studies, analyzing the effects of different demographic variables in more detail will help reveal the reasons underlying the differences in candidates' digital competencies. It is recommended that the effects of factors such as the infrastructure provided by educational institutions be considered from multiple dimensions. Moreover, long-term studies should be conducted to evaluate how candidates' experiences with technology integration reflect on classroom practices.

Although the present study did not examine the specific content or instructional approaches of the teacher education programs at the five participating universities, the recommendations offered are grounded in the observed trends and supported by prior literature. The focus on pre-service music teachers is intentional, as music education

involves distinct pedagogical practices—such as real-time performance, creative composition, and multimodal feedback—that uniquely align with AI-supported instructional tools. The findings suggest that strengthening music teacher candidates' general technology integration skills may serve as a foundational step toward more effective and innovative use of discipline-specific digital tools in future classrooms. In practice, music teacher training programs need to update their current curricula in the areas of technology integration and artificial intelligence literacy and conduct studies that will increase candidates' digital competencies. These updates can be structured as interactive learning modules, project-based application workshops, and interdisciplinary collaboration projects. Educational institutions should create awareness about the ethical and responsible use of technological tools through continuing education seminars and mentor support programs for teacher candidates. Applied projects and laboratory studies that will increase candidates' digital pedagogical skills should be made an integral part of the program. The fact that faculty members constantly renew their digital competencies and follow current technological developments should be reflected in candidates' education. Education policymakers should provide the necessary infrastructure and resource support to adapt to the digital transformation process of teacher training programs. In practice, it is recommended that digital portfolio applications be used to support candidates' personal development in technology integration and artificial intelligence literacy. These portfolios can be important tools that document candidates' professional development processes and their progress in using technology.

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## Data Availability Declaration

While the primary datasets utilized in this study are not publicly accessible due to certain constraints, they are available to researchers upon a formal request. The authors have emphasized maintaining the integrity of the data and its analytical rigor. To access the datasets or seek further clarifications, kindly reach out to the corresponding author. Our aim is to foster collaborative academic efforts while upholding the highest standards of research integrity.

## Author Contributions

The sole author of this research, Özlem Kılınçer, was responsible for the conceptualization, methodology formulation, data collection, analysis, and interpretation. Furthermore, [Özlem Kılınçer took charge of drafting the initial manuscript, revising it critically for vital intellectual content, and finalizing it for publication. The author has read and approved the final manuscript and takes full accountability for the accuracy and integrity of the work presented.

### *Author(s)' statements on ethics and conflict of interest*

***Ethics statement:*** We hereby declare that research/publication ethics and citing principles have been considered in all the stages of the study. We take full responsibility for the content of the paper in case of dispute.

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