

# THE INFLUENCE OF ARTIFICIAL INTELLIGENCE-ASSISTED MUSIC TEACHING ON STUDENTS' LEARNING OUTCOMES

**Long Ma**

**An Independent Study submitted in partial fulfillment of the Requirements for the Degree of Master of Management Program in Creative Industries Management**
**Rattanakosin International College of Creative Entrepreneurship**
**Rajamangala University of Technology Rattanakosin**
**Academic Year 2026**

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**Degree**: Master of Management (Creative Industries Management)
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# ABSTRACT

The objectives of this study were (1) to examine the effects of facilitating conditions and perceived ease of use on perceived usefulness and students' attitudes toward AI-assisted music teaching, (2) to investigate the effects of perceived usefulness and attitude on students' behavioral intention and actual use, and (3) to examine the effects of perceived usefulness and actual use on students' learning outcomes.

This study employed a quantitative survey research design. The respondents were 511 university students majoring in music from universities across different regions of China who had experience with AI-assisted music teaching tools. They were selected using purposive and convenience sampling. Data were collected through a structured questionnaire measuring facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and learning outcomes. The data were analyzed using descriptive statistics, measurement model assessment, and structural model assessment.

The major findings: (1) Facilitating conditions had significant positive effects on perceived ease of use and perceived usefulness, indicating that adequate resources and support enhanced students' perceptions of AI-assisted music teaching. Perceived ease of use also positively influenced perceived usefulness and attitude, while perceived usefulness significantly improved students' attitudes; (2) Perceived usefulness and attitude significantly affected behavioral intention, which in turn had a strong positive effect on actual use of AI-assisted music teaching; (3) Both perceived usefulness and actual use significantly influenced students' learning outcomes, with actual use showing a slightly stronger effect. Overall, the findings indicate that AI-assisted music teaching enhances students' learning outcomes when students perceive the technology as useful and easy to use, develop positive attitudes and behavioral intentions, and actively engage with AI-assisted learning tools.

**Keywords**: Artificial intelligence-assisted music teaching, Learning outcomes, Technology Acceptance Model, Constructivist Learning Theory, Music education

Advisor's Signature……..…….

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Name-Surname
Long Ma

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# CHAPTER 1
# INTRODUCTION

The opening section sets out the general context and scope of this study through outlining major issues that motivate the present investigation. It first reviews relevant developments in education and technology linked to AI-assisted music instruction before identifying the central research problem addressed in this investigation. The chapter then discusses the significance of the research, followed by the research questions and objectives that structure this inquiry. In addition, it provides a concise description of the methodological design and clarifies the delimitations established for the investigation. Collectively, these sections establish an integrated foundation for the theoretical discussion, methodological procedures, and empirical analysis presented in the subsequent chapters.

## 1.1 Research Background

### 1.1.1 Research problem statement

With the accelerated development of artificial intelligence (AI), teaching and learning contexts have undergone profound changes, and AI is increasingly regarded as an important catalyst for reform and modernization within education systems (Wang et al., 2024). As machine learning, natural language processing, and learning analytics have continued to advance, AI-based tools have been increasingly embedded in multiple educational scenarios, including face-to-face instruction, digital learning platforms, and assessment-related activities (Tan et al., 2025). These technologies support personalized learning, adaptive instruction, and intelligent feedback, which shift traditional teaching methods toward more student-centered approaches. According to UNESCO (2023), AI technologies can improve learning efficiency, support individualized instruction, and enhance students' learning outcomes (Lee et al., 2025).

This research is driven by the increasing expectation that educational institutions should respond to fast-growing digital innovation while putting AI-focused education policies into practice. At global and domestic levels, public authorities and educational

bodies have encouraged the use of AI in instructional practices to advance educational reform, develop learners' digital capabilities, and raise teaching effectiveness. Consistent with this direction, UNESCO (2023) calls for a people-oriented framework for the educational use of AI, emphasizing the need to improve institutional governance, teacher and staff capacity, and the evaluation of learning results. In the Chinese context, the national smart-education platform and wider digitalization policies reflect China' s stronger effort to develop intelligent learning resources and build technology-supported learning spaces (Ministry of Education of the People's Republic of China, 2024). Although these initiatives create favorable conditions for AI-supported teaching, they do not by themselves ensure that learners will accept, use, or benefit from AI tools in particular subject contexts.

The growth of digital learning environments has widened role of AI in education. Online platforms, intelligent tutoring systems, and AI-based learning applications enable students to obtain resources more flexibly and receive feedback more quickly (Mohd Amin et al., 2025). Empirical research further indicates that AI-enhanced educational settings can foster stronger learning motivation, encourage active participation, and contribute to improved academic achievement (Villaver & Cabigas, 2025). However, AI technologies can generate educational benefits only when students are prepared to accept them and use them purposefully, rather than when such tools are simply made available. In this process, students' judgments about functional usefulness, operational simplicity, and learning relevance are central to whether AI-supported learning can be effectively realized.

Although higher education institutions are actively exploring AI technologies, challenges remain regarding institutional readiness, student support, ethical concerns, and effective integration into teaching practices (EDUCAUSE, 2024). Studies on AI-enabled learning also suggest that its instructional contribution depends on how learners evaluate the technology, how effectively they interact with it, and how actively they use the system in real learning activities (Bai et al., 2025). Against this background, increasing scholarly attention has been given to the factors that influence whether students are ready to accept AI tools and apply them effectively, making this issue an important focus in current educational technology research.

In music education, learning outcomes are closely related to continuous practice, timely feedback, and personalized instruction. The second source of the research problem arises from the inherent limitations of traditional music teaching. Music learning requires repeated practice, individualized guidance, and continuous performance evaluation. However, traditional music instruction often relies on limited classroom time and teacher-centered approaches, making it difficult to provide personalized feedback to every student (Tan et al., 2025). In many cases, students receive feedback only during scheduled lessons, resulting in delayed evaluation of practice performance and limited opportunities for immediate correction. These constraints may reduce learning efficiency and hinder the development of musical skills. AI-assisted music teaching has the potential to address these limitations by providing intelligent evaluation, adaptive learning content, and real-time feedback. Studies have shown that AI-assisted music learning systems can improve students' engagement and performance outcomes by offering personalized learning experiences (Du, 2025). Recent studies indicate that AI-assisted music learning systems can provide real-time feedback on pitch accuracy, rhythm, tempo, and performance quality, thereby supporting independent practice and personalized learning (Ou et al., 2025). These capabilities suggest that AI technologies may help overcome the challenges of insufficient individualized feedback, limited instructional time, and delayed assessment in music education. Nevertheless, the effective adoption of AI-supported music teaching is determined by whether students have the readiness and ability to use these AI tools effectively.

In technology acceptance studies, users' perceptions, attitudes, intentions, and usage behaviors are commonly treated as major variables for explaining how technology-supported learning systems are adopted. More precisely, this framework is built around five key elements: perceived usefulness, perceived ease of use, attitude, behavioral intention, and actual system use (Chen et al., 2025; Liang & Reiss, 2025). When students view AI technologies as useful, easy to access, and relevant to their learning requirements, they tend to develop more favorable judgments of these systems and show greater readiness to apply them in their learning practices. Such favorable perceptions often encourage more sustained interaction with AI-supported learning tools and promote greater engagement throughout the learning process. Conversely, if AI applications are considered difficult to navigate, unreliable, or poorly aligned with learning requirements,

students may become reluctant to adopt them, thereby reducing the educational benefits that these technologies can deliver.

At the same time, AI-supported music instruction faces practical and psychological barriers. Some students may continue to rely on traditional approaches or may feel uncertain about the role of AI in music learning. When students have negative attitudes toward AI-assisted learning, they may be less willing to engage with these technologies, which may reduce their learning outcomes. Students' attitudes toward educational technologies significantly influence learning engagement and academic performance (Liang & Reiss, 2025). Some AI-based music systems require technical skills and training, which may create difficulties for students. When learners regard these AI tools as technically demanding or hard to operate, they may feel frustrated and become less motivated, thereby weakening their learning performance (Novak et al., 2023). Accordingly, students' views of the usability of AI-assisted music teaching systems are important for assessing the educational benefits and teaching effectiveness associated with these tools.

Another essential determinant of successful learning is students' perception of the educational value offered by AI-assisted music technologies. When these systems are viewed as capable of strengthening musical competence and enhancing learning effectiveness, learners typically demonstrate a greater willingness to incorporate them into their study practices (Niu, 2026). Perceived usefulness positively influences students' learning motivation and academic achievement in technology-enhanced learning environments (Nuryakin et al., 2023). Within music education, positive evaluations of AI-assisted learning tools can encourage greater involvement in instructional activities while contributing to stronger educational achievement. Students who recognize the value of AI support tend to engage more consistently in learning and demonstrate better learning performance.

The successful implementation of AI-assisted music learning also depends on the extent to which appropriate institutional and technical support is available. Adequate digital infrastructure, sufficient access to learning technologies, and continuous instructional assistance from teachers collectively help students apply AI-supported music learning resources more efficiently while reducing usage barriers (Cabellos et al., 2024). When facilitating conditions are insufficient, students can face obstacles in working with

AI-supported learning resources, which may weaken their participation and negatively influence learning results. Existing studies indicate that sufficient facilitating conditions can promote learners' acceptance of digital educational tools while strengthening their academic performance (Feng et al., 2025). Accordingly, the quality of institutional, technical, and instructional support is a crucial determinant of how effectively AI-assisted music teaching can be implemented in educational practice.

Furthermore, even when AI technologies are available, students may not actively use them. If students do not engage with AI-assisted music teaching tools, the potential benefits of these technologies cannot be realized. Research indicates that students' behavioral intention significantly predicts actual use behavior, which directly influences learning outcomes (Nurtanto et al., 2025). Taken together, accessible institutional, technical, and instructional assistance forms a necessary basis for embedding AI-based tools effectively in music education.

Although AI-supported music teaching has received increasing attention in educational digitalization and is viewed as a possible solution to long-standing problems in music education, its learning benefits can only be achieved when students are prepared to accept these tools and participate in their use. Existing studies have discussed technology acceptance in general educational contexts, but less research has examined how facilitating support, ease-of-use perception, perceived usefulness, learner attitude, intention to use, and actual use jointly influence university students' learning results in AI-based music education. Therefore, the present study aims to fill this research gap by examining the connections among these variables and clarifying how AI-supported music teaching may improve students' learning outcomes in higher music education.

From a wider viewpoint, AI-supported music teaching affects education through the joint of technological conditions, learning environments, and learner factors, rather than through the simple presence of AI tools. External support, along with learners' perceptions, attitudes, intention to use, and actual use behavior, determines how far AI can improve learning experiences. Therefore, analyzing the relationships among these elements is important for explaining variations in students' learning outcomes and for clarifying the role of AI-supported music teaching within higher education.

### 1.1.2 Research gap

Existing reviews pay limited attention to AI literacy and theoretical development, and that many studies rely on existing frameworks in a descriptive way rather than empirically testing or extending them (Zhang et al., 2024). This pattern suggests that, although AI in education is a rapidly growing field, its theoretical foundations are still not sufficiently consolidated.

The field has grown steadily and that current studies mainly focus on personalized learning systems, recommendation tools, intelligent assessment, teaching optimization, motivation, professional skills, and creativity (Onyebuchi et al., 2024). This indicates that the existing literature has paid considerable attention to what AI can do in music teaching, but less attention to how students' acceptance and use of AI-assisted instruction translate into educational outcomes through a coherent explanatory model.

Research on technology acceptance in music education has predominantly concentrated on the experiences of pre-service music teachers, whereas relatively limited attention has been given to learners themselves. He and Ren (2025) explored future music educators' adoption of generative AI and found that performance expectancy, effort expectancy, facilitating support, compatibility, and perceived risk had significant effects on their adoption intention and later usage behavior. Although these findings contribute to understanding AI adoption within teacher education, they provide only limited evidence regarding how university students engaged in AI-assisted music learning evaluate these technologies, develop intentions to use them, and translate such intentions into improved learning outcomes. Consequently, existing studies in the field of AI-supported music education still provide relatively limited evidence regarding learners' technology acceptance and its connection with educational outcomes.

Some studies confirm that digital or AI-supported music learning can improve certain outcomes, but these gains are often limited to specific dimensions. Yang et al. (2025) found that a long-term online music course significantly improved musical creativity and cultural understanding, but did not significantly improve music perception, analysis, or performance skills. More broadly, a meta-analysis on GenAI and learning outcomes reported a moderate positive overall effect, yet also found very high heterogeneity across studies, which means that the effects of AI vary substantially across contexts, subjects, and research designs (Gökoğlu & Erdoğdu, 2025). Taken together, learning outcomes in

AI-supported environments are multidimensional and context-sensitive, and current evidence is still insufficiently integrated to explain why some AI-supported learning experiences produce stronger outcomes than others.

A further gap concerns the connection between AI-assisted music teaching and constructivist learning. Saarela et al. (2026) noted that significant obstacles remain in effectively combining digital technologies with constructivist learning principles in music education, and proposed a framework to address creativity development in that context. However, this research stream mainly examines digital instruments and creativity development, rather than treating AI-assisted music teaching as a technology acceptance process associated with perceived usefulness, perceived ease of use, behavioral intention, actual use, and wider learning outcomes. Therefore, the constructivist dimension and the technology acceptance dimension have largely developed in parallel rather than being systematically integrated in music education research.

Drawing on the reviewed literature, studies of AI-assisted music education have largely centered on technological applications, whereas the processes by which AI affects students' learning outcomes have received insufficient scholarly attention. In addition, student-centered evidence remains relatively limited, and learning outcomes are often examined in isolated dimensions rather than within an integrated framework. Moreover, constructivist learning perspectives and technology acceptance perspectives have rarely been combined in AI-assisted music education research. Therefore, further investigation is required to explore the extent to which environmental support factors, users' perceptions of technology accessibility and value, affective evaluations, intention to adopt, and subsequent engagement behaviors contribute to students' learning outcomes within AI-supported music education contexts.

## 1.2 Significance of the Study

### 1.2.1 Theoretical Significance

The present study contributes to the theoretical explanation of AI-enabled education by integrating TAM with constructivist learning views, thereby offering a broader account of how AI-supported music instruction shapes students' learning effectiveness. Although TAM has been widely used in prior studies to examine the acceptance of digital learning tools, most research has mainly focused on users' acceptance intention and later technology-

use behaviors, with less attention paid to how these acceptance processes affect educational outcomes (Jiang et al., 2025). However, limited research has extended TAM to examine its influence on students' learning results, particularly within AI-assisted music education. By incorporating learning outcomes as an important dependent construct, the research extends TAM from technology acceptance to educational effectiveness, thereby enriching the theoretical application of TAM in educational research.

In addition, the present research adds to constructivist learning theory by exploring the ways in which AI-supported music teaching promotes students' active learning and knowledge construction. Constructivist perspectives on learning suggest that knowledge acquisition is not a passive process but is developed through learners' active engagement, meaningful interactions, continuous feedback, and practical experiences (Do et al., 2023). AI-assisted music teaching provides personalized feedback, adaptive learning environments, and interactive learning experiences, which align with constructivist learning principles (Ou et al., 2025). By investigating how AI-supported instructional practices shape students' educational achievements, this present research offers quantitative evidence on the relevance and applicability of constructivist learning principles within digitally enhanced music education environments.

Furthermore, this research advances the connection between technology adoption perspectives and educational effectiveness studies by developing an integrated analytical framework. Previous investigations have often explored learners' acceptance of technological tools and their academic outcomes as separate research streams, resulting in limited understanding of the mechanisms linking technology adoption processes with learning performance. To address this limitation, the current study incorporates contextual support, perceptions of usability and instructional value, learners' evaluative responses, adoption intentions, and actual engagement behaviors into a unified framework to examine how AI-supported music instruction influences students' learning effectiveness. This comprehensive framework broadens theoretical insights into the interaction between AI-based teaching practices and learner development, while providing a foundation for future investigations concerning AI applications within the field of music education.

Overall, this thesis extends current knowledge of AI-enabled learning by applying an integrated theoretical perspective that combines technology adoption frameworks with constructivist approaches in music education settings. Through analyzing how contextual

support, users' perceptions of technological accessibility and educational value, attitudinal evaluations, adoption intentions, and patterns of AI utilization relate to students' academic development, this study establishes a broader explanatory model for understanding the educational impacts of AI-supported music instruction. The findings offer useful theoretical implications for future research on how AI contributes to educational innovation and technology-supported music learning.

**1.2.2 Practical Significance**

The study offers practice-oriented implications for music educators by showing how AI-enabled instructional methods may support the improvement of students' learning performance. Through analyzing the factors that influence learners' acceptance and participation in AI-driven music learning, educators can better understand how such digital tools can be integrated into teaching practice in an effective manner. The findings suggest that teachers can develop more adaptive instructional strategies, foster greater learner participation, and facilitate personalized learning pathways that support the improvement of students' musical abilities and overall academic achievement.

This study also offers implications for educational institutions. These improvements can enhance students' acceptance of AI-assisted music teaching and promote effective implementation of AI technologies in music education. Furthermore, educational organizations may draw upon the research evidence generated from this investigation to formulate strategic initiatives that promote the implementation of AI-enhanced learning environments.

Moreover, this research provides valuable guidance for designers and developers of AI-supported music learning platforms. By gaining insights into learners' evaluations of technological benefits, accessibility, and emotional responses toward AI-based instructional applications, developers can create more intuitive, adaptive, and pedagogically effective learning solutions. Enhancing system design, operational convenience, and functional capabilities may strengthen students' engagement with AI-driven music learning tools and ultimately contribute to improved educational outcomes.

Overall, this research generates meaningful practical implications for multiple stakeholders, including music educators, academic organizations, and AI technology designers.

### 1.3 Research Questions

RQ1. How do facilitating conditions and perceived ease of use influence perceived usefulness and students' attitudes toward AI-assisted music teaching?

RQ2. How do perceived usefulness and attitude influence students' behavioral intention and actual use of AI-assisted music teaching?

RQ3. How do perceived usefulness and actual use of AI-assisted music teaching influence students' learning outcomes?

### 1.4 Research Objectives

RO1. To examine the influence of facilitating conditions and perceived ease of use on perceived usefulness and students' attitudes toward AI-assisted music teaching.

RO2. To investigate the influence of perceived usefulness and attitude on students' behavioral intention and actual use of AI-assisted music teaching.

RO3. To examine the influence of perceived usefulness and actual use of AI-assisted music teaching on students' learning outcomes.

### 1.5 Methodology

A quantitative approach was adopted in this research to explore how AI-enhanced music learning practices affect students' educational outcomes. The conceptual framework was established by drawing upon the TAM and Constructivist Learning Theory to explain mechanisms underlying students' engagement with AI-supported instruction. Specifically, this study examined the effects of contextual support, users' perceptions of technological accessibility and learning value, attitudinal responses toward AI-based music education, adoption intentions, actual engagement behaviors, and their associations with students' learning performance.

The participants in this investigation were undergraduate and postgraduate students who had previously engaged in AI-based music learning activities. Empirical information was gathered using a standardized questionnaire developed to record learners' views, acceptance-related behaviors, and learning experiences within AI-enabled music education. The indicators were adapted from validated instruments used in earlier research and then contextualized according to the characteristics of AI-enabled music learning. This survey

form was used to measure the constructs included contextual support, perceived technological accessibility, perceived educational value, learners' attitudinal evaluations, adoption intentions, actual engagement with AI learning tools, and learning performance. All constructs were evaluated using a five-level Likert response format, with options ranging from strong disagreement to strong agreement.

The empirical data for this study were gathered through an online questionnaire distributed among university students who had previous experience with AI-supported music learning. After incomplete and invalid questionnaires were excluded, the remaining valid responses were used for further statistical analysis. Prior to the formal survey, a pilot test was carried out to assess whether the measurement items were clear, consistent, and suitable for the research context. Scale reliability was assessed through Cronbach' s alpha, and every construct produced a coefficient higher than the recommended threshold of 0.70, indicating that the measurement scales had acceptable internal consistency.

After the data had been screened and organized, SEM was used to conduct the statistical analysis. Descriptive analysis was first performed to summarize participants' demographic profiles and general background information. The measurement model was then tested in terms of item reliability, convergent validity, and discriminant validity. After confirming that the measurement model met the required standards, the hypothesized paths among the proposed variables were examined by referring to path coefficients, significance values, and related statistical results.

Overall, this investigation employed a quantitative methodology integrating survey-based measurement and SEM analysis to examine how AI-enhanced instructional practices in music contribute to students' learning outcomes.

### 1.6 Delimitation

First, the research population was limited to university-level learners who had previous exposure to AI-supported music learning activities. This population was selected because students in higher education settings generally have greater opportunities to interact with AI-driven learning technologies through academic courses and independent practice. However, the conclusions derived from this study should be interpreted cautiously, as they may not directly represent learners in elementary education, secondary education, or specialized professional music training contexts.

Second, the analytical framework concentrated on constructs originating from TAM and constructivist perspectives. Specifically, the study examined contextual support, perceived technological accessibility, perceived educational value, learners' attitudes toward AI-based music instruction, adoption intentions, actual engagement behaviors, and learning performance. Other influential elements, including students' digital competence, motivational characteristics, previous musical background, and instructors' technological capabilities, were beyond the scope of the present investigation and therefore were not incorporated into the proposed model.

Third, this study examined students' perceptions of AI-assisted music teaching rather than evaluating specific artificial intelligence tools or platforms. Different AI-assisted music systems may provide different features and functionalities, which may influence students' perceptions and learning outcomes. However, the present research centered on students' overall views of AI-supported music teaching, instead of making comparisons among particular technologies.

Fourth, the investigation employed a quantitative methodology based on a systematically designed survey instrument. Although self-reported data are widely used in technology acceptance research, objective measures such as performance assessments and system usage data were not included.

Finally, the findings need to be understood in relation to the particular educational context and period in which the study was carried out. With the ongoing development of AI technologies and learners' increasing familiarity with AI-based tools, students' perceptions and acceptance of AI-supported music instruction may continue to change in the future.

## 1.7 Conclusion

This chapter reviewed the development and significance of AI-supported music education and explained why it is necessary to examine its relationship with students' learning performance. On the basis of the gaps found in earlier research, the study developed its research questions and objectives to direct the present inquiry. In addition, the methodological approach and research scope were briefly described to clarify the focus and boundaries of the study. Overall, this chapter provides an initial foundation for building the conceptual framework and conducting the empirical analysis in the following chapters.

# CHAPTER 2
# LITERATURE REVIEW

This chapter builds the theoretical basis for examining how AI-enhanced music instruction is related to students' educational performance. Through reviewing prior empirical studies and related theoretical views, it clarifies the major concepts and mechanisms that support the present study. The chapter contains four main parts. Section 2.1 introduces the context and development of AI-supported music education and reviews relevant empirical studies in this area. Section 2.2 discusses the theories used in this research, namely TAM and Constructivist Learning Theory, which serve as the foundation for explaining technology acceptance and learning processes. Section 2.3 examines the core variables incorporated into the proposed research model, including contextual support, perceived technological accessibility, perceived educational value, attitudes toward AI-based music instruction, adoption intentions, actual engagement with AI learning tools, and students' learning performance. Section 2.4 integrates the reviewed literature to construct the conceptual model and formulate the research hypotheses. Through this systematic organization, the chapter provides the necessary theoretical justification and empirical support for the proposed framework and facilitates the interpretation of subsequent analytical results.

## 2.1 Research context

### 2.1.1 Artificial Intelligence in Education

The integration of artificial intelligence has increasingly shaped digital evolution of higher education, especially following the rapid development and widespread emergence of generative AI applications after 2020 (Schmidt et al., 2025). Governments and international education agencies have gradually acknowledged AI' s capacity to reshape teaching methods, learning environments, and students' educational experiences. UNESCO stated that AI is promoting changes in education systems through intelligent

tutoring, individualized learning routes, and automated feedback function(Chigbu & Makapela, 2025). However, it also emphasized that the effectiveness of AI in education is closely related to learners' interaction with such technologies and the extent of institutional support for their use (Maamor et al., 2024). These developments indicate that applying AI in education is not only a technical issue, but also involves pedagogical adjustment and learner-related conditions that may influence students' academic performance.

The ongoing expansion of digital learning environments has promoted the wider use of AI applications across universities. AI-supported digital learning contexts can increase students' participation and offer more flexible learning options, particularly at the tertiary education level (Imran et al., 2024). Likewise, universities are making greater use of AI-enabled learning systems, intelligent tutoring applications, and automated evaluation tools to strengthen teaching quality and improve students' academic performance (Ruano-Borbalan, 2025). These AI-driven solutions enable learners to access individualized instructional assistance and responsive learning feedback, offering particular advantages for practice-oriented fields such as music education.

Moreover, AI use in universities has gradually influenced how learners participate in learning activities and how they achieve academic progress. Current AI-based educational practices are commonly reflected in various intelligent systems, including AI-supported tutoring environments, adaptive instructional platforms, and automated evaluation mechanisms (Létourneau et al., 2025). These AI-enabled applications offer learners customized educational support and ongoing performance feedback, thereby facilitating improvements in academic achievement. Nevertheless, the outcomes generated by such systems are strongly influenced by learners' willingness to adopt the technology, their perceptions of its accessibility and value, and the extent to which they actively engage with AI-based learning resources.

In China, the Ministry of Education has introduced “Smart Education of China” initiative, which aims to accelerate the application of AI and digital innovations across teaching and learning contexts. The initiative highlights the development of intelligent educational platforms, adaptive learning spaces, and the sharing of digital academic resources among universities (Ma, 2025). The policy also encourages universities to explore AI-supported teaching models to improve students’ learning outcomes and promote educational innovation. These policy developments demonstrate that AI-assisted

learning has become an important direction for higher education development, particularly in China.

Despite the increasing adoption of AI technologies, several contextual challenges remain. The UNESCO (2023) report emphasized that many educational institutions still lack adequate infrastructure, teacher training, and technical support for AI implementation (Ma, 2025). Similarly, Similarly, U.S. education authorities also raised issues concerning usability, accessibility, and students' acceptance of AI tools (Mustofa et al., 2025). These issues demonstrate that educational value of artificial intelligence is shaped by more than technological advancement alone; it also relies on learners' cognitive evaluations, emotional responses, and patterns of technology engagement. These factors are particularly relevant to this study, which examines how students accept and use AI-assisted music teaching and how these factors influence learning outcomes.

Therefore, the present educational context shows that AI is becoming more widely used in universities, supported by technological progress, policy promotion, and the expansion of digital learning. Nevertheless, the influence of AI-supported learning environments on education depends largely on whether learners are willing to accept such tools and how they actually engage with them, as these factors affect learning performance. To examine these processes further, this study adopts TAM as a theoretical perspective to analyze students' perceptions, acceptance, and interaction with AI-based music instruction. Constructivist learning theory is also used to explain how AI-supported learning contexts affect students' learning results through active participation and knowledge construction. Together, these theories provide a conceptual foundation for addressing the research questions and supporting the present investigation.

### 2.1.2 Artificial Intelligence in Music Education

Over the past few years, AI has brought changes to many dimensions of music education, supported by the development of intelligent learning platforms, generative AI tools, and adaptive teaching systems (Tan et al., 2025). Artificial intelligence applications have been increasingly integrated into multiple areas of music education, such as performance assessment, creative composition, auditory training, and interactive learning settings (Chen & Sun, 2024). These technologies enable personalized learning experiences and improve teaching efficiency, which has attracted growing attention in higher education institutions and music programs.

AI systems can analyze students' learning behaviors, performance data, and skill levels to provide adaptive learning content. Generative AI tools are able to design individualized learning routes automatically and offer students instant feedback during practice. These functions help students identify weaknesses and improve their musical skills more efficiently. AI-assisted music learning can improve conventional learning approaches and increase learning efficiency through timely feedback and individualized instructional support (Ou et al., 2025).

Artificial intelligence is also widely used in music performance training and practice. AI-based systems can evaluate pitch accuracy, rhythm, and tone quality, which supports students' independent practice outside the classroom. AI-supported practice tools enhanced students' self-confidence in learning and their instrumental performance (Zhu, 2026). The results showed that students using AI-supported tools maintained stable learning confidence, while students in traditional learning environments experienced declines in confidence as tasks became more difficult (Bognár & Khine, 2025). These results indicate that AI-supported music learning may improve students' performance while also strengthening their motivation to learn.

In addition, artificial intelligence has been applied in music creation and collaborative learning. AI systems can generate musical ideas, assist composition, and support collaborative creativity. These tools allow students to explore new musical styles and improve creative abilities. AI is able to evaluate students' learning conditions and adjust instructional materials, helping them understand complex musical concepts more effectively and supporting knowledge construction as well as deeper learning (Cheng, 2025).

Despite these advantages, several challenges remain in AI-assisted music education. Technical limitations such as algorithm accuracy and system adaptability may affect learning effectiveness. Other studies have raised issues concerning learner data protection, algorithmic bias, and the dependability of AI-produced materials. Such problems may affect students' trust in AI-assisted learning systems and their readiness to use them. Existing research further suggests that ethical risks, information security, and technical constraints continue to act as major obstacles to AI adoption in music education (Herington et al., 2026).

Moreover, the success of AI-supported music learning is strongly related to whether learners are ready to accept such tools and how they interact with AI-driven instructional resources. The educational advantages offered by AI applications cannot be fully realized unless students actively participate in and incorporate these tools into their learning processes. Prior studies have shown that learners' judgments about technological usefulness, ease of access, and expected learning benefits strongly affect their choices to use AI-supported learning systems. Therefore, examining the elements that shape students' technology acceptance and participation in AI-assisted music instruction is important for explaining how AI applications may support better learning performance.

Overall, AI has opened up new possibilities for music teaching and learning by supporting individualized learning, performance practice, and creative development. However, the effectiveness of AI-assisted music teaching depends on students' acceptance, usage behavior, and learning environments. These environmental and learner-related conditions are closely aligned with the central focus of the present research, which explores the processes through which university music students perceive, adopt, and engage with AI-supported music instruction, as well as how these factors contribute to variations in learning performance.

**2.1.3 Artificial Intelligence in Higher Education in China**

In China, AI has gradually become an important driver of educational modernization, particularly in universities and other higher education institutions. In recent years, national policy initiatives have encouraged the use of AI and digital innovation in teaching practices, with the purpose of improving instructional quality and providing students with better learning experiences. Guided by these policy measures, universities have moved more quickly to build AI-enabled learning settings, smart education platforms, and data-based instructional approaches.

In addition, the Ministry of Education of China has promoted educational digitalization through national initiatives (Ma, 2025). The "Smart Education of China" platform represents a national effort to expand digital educational resources and foster intelligent learning ecosystems within universities. China's Ministry of Education (2022) stated that progress in digital education has supported the wider use of AI across universities, making instructional processes more efficient and improving students' learning experiences. These changes show that AI is gradually being integrated into university teaching and learning contexts in China.

Universities in China are actively introducing AI-based tools into their teaching practices. Artificial intelligence has been increasingly incorporated into various educational applications, including AI-supported tutoring systems, data-driven learning analytics, automated evaluation processes, and adaptive personalized learning environments (Fortuna et al., 2025). These technologies allow educators to monitor students' learning progress and provide individualized learning support. Research has shown that AI-assisted learning environments in Chinese universities can improve student engagement and learning performance (Huang, 2024). Furthermore, AI technologies support flexible learning opportunities, which enable students to access learning resources and receive feedback outside classroom settings.

Despite the rapid advancement of AI applications in Chinese universities, their effective adoption remains constrained by several practical and human-related factors. Issues such as digital infrastructure readiness, educators' technological competencies, and learners' willingness to engage with AI-based tools may significantly affect the successful integration of AI-supported learning practices and their potential educational benefits (Zhu, 2024). When universities do not provide adequate infrastructure or technical assistance, students may experience obstacles in using AI-supported learning resources. Such difficulties can weaken students' participation and learning results. Moreover, learners' judgments about the usefulness and ease of use of AI technologies strongly affect whether they are prepared to accept AI-supported learning systems. Therefore, examining students' acceptance and actual use behavior is necessary for enhancing the effectiveness of AI-assisted learning in China' s higher education context.

Moreover, intelligent tutoring solutions and AI-enhanced learning platforms has become increasingly common among university learners in China. These digital resources allow students to participate in self-directed study, develop problem-solving abilities, and strengthen disciplinary skills. Nevertheless, the effectiveness of AI-supported learning depends largely on how learners understand, use, and embed such tools within their academic practices. Students who actively use AI tools in their learning processes tend to obtain stronger academic results and show higher learning engagement (Singh et al., 2026). Such evidence emphasizes the need to analyze students' perceptions and use patterns within AI-assisted learning contexts.

Overall, artificial intelligence is increasingly integrated into higher education in China through national policies, institutional initiatives, and technological advancements. Nevertheless, the educational impact of AI-supported learning is shaped by multiple factors, including learners' willingness to adopt the technology, their patterns of use, and the surrounding instructional context. These contextual elements are closely connected with the focus of this research, which analyzes how Chinese university students majoring in music accept and use AI-assisted music teaching, as well as how such elements affect their learning results. Accordingly, this study employs TAM to examine the factors behind students' adoption choices and technology-related behaviors, and also integrates Constructivist Learning Theory to explain how AI-supported music learning affects students' educational growth and learning performance.

### 2.1.4 AI Music Education for University Students

Artificial intelligence has increasingly been applied in music education for university students, particularly in professional music training contexts. Compared with general learners, university music students require intensive practice, individualized instruction, and continuous feedback (Jiang et al., 2025). These learning characteristics make artificial intelligence particularly suitable for music education at the university level. Recent studies indicate that AI-assisted music learning systems can support performance training, music composition, ear training, and music theory learning (Merchán Sánchez-Jara et al., 2024). These intelligent learning systems provide learners with immediate instructional feedback and tailored educational assistance, thereby facilitating more efficient learning processes and contributing to improved academic achievements.

In addition, AI-assisted music education provides flexible learning opportunities for university students. Music students often need extended practice time beyond classroom instruction. AI-supported learning resources enable students to practice on their own and obtain timely feedback (Yang & Li, 2025). AI-enabled practice systems have shown promise for improving learners' musical performance, self-confidence, and active involvement in educational activities. These empirical observations indicate that technology-enhanced music learning contexts may foster stronger learning motivation while providing effective support for the gradual development of students' musical competencies (Madhusudhanan, 2025).

The Ministry of Education of China has highlighted the importance of strengthening AI-related education in universities by encouraging the establishment of both foundational and discipline-specific AI courses, as well as advancing the development of intelligent course systems within higher education institutions (Ministry of Education of the People's Republic of China, 2025). In addition, the White Paper on China's Smart Education reported that the Smart Higher Education Platform had launched a dedicated section for "General AI Courses," including 104 high-quality public and foundational AI courses from 47 universities, which indicates that AI-related teaching resources are being introduced across different types of higher education institutions rather than being limited to technology-oriented universities (Smart Learning Institute of Beijing Normal University, 2025). In the field of music education, existing research also shows that music-related majors and courses in China are offered not only by professional music and art colleges but also by comprehensive universities and teacher-training universities, reflecting the diversified institutional structure of higher music education (Zheng, 2025). Therefore, collecting data from music and arts universities, normal universities, comprehensive universities is appropriate because AI-assisted music teaching is increasingly relevant to professional training, teacher preparation, general music education, and applied music learning.

Artificial intelligence also supports creative learning in music education. University music students are expected to develop creativity and innovation skills. AI-based composition tools and music generation systems allow students to explore new musical ideas and experiment with different styles (Zhang, 2025). These technologies support constructivist learning environments by encouraging active learning and knowledge construction. AI-assisted creative tools can enhance students' musical creativity and deepen their understanding of music concepts (Wang & Zhang, 2025).

Although AI-supported music learning provides valuable opportunities for university students, its successful implementation is accompanied by several practical and behavioral barriers. Some learners may not be sufficiently familiar with AI-based educational applications, which may lower their confidence and reduce their readiness to use such tools in learning. In addition, students' judgments about the usefulness, accessibility, and practical benefits of AI technologies strongly influence their acceptance of AI-supported music learning systems. Their general views of AI also affect their willingness to use

these technologies and their actual usage patterns in educational contexts (Niu, 2026). These empirical insights indicate that learners' acceptance of artificial intelligence technologies represents a key condition influencing the successful implementation and educational impact of AI-supported music learning.

Moreover, the educational value of AI-supported music learning depends largely on how students interact with and apply intelligent technologies during their learning process. Students who make active use of AI-assisted learning platforms tend to achieve better performance and stronger learning outcomes. However, students who do not actively engage with AI technologies may not benefit from these tools. Learners' actual engagement with AI-based educational technologies represents a critical factor contributing to enhanced learning outcomes within technology-supported instructional contexts (Maamor et al., 2024). Therefore, examining students' acceptance and usage behavior is essential for understanding the influence of AI-assisted music education on learning outcomes.

Overall, artificial intelligence provides new opportunities for university music students by supporting personalized learning, performance training, and creative development. However, the effectiveness of AI-assisted music education depends on students' perceptions, acceptance, and usage behavior. These contextual factors are closely related to this study, which focuses on Chinese music-major university students and examines how AI-assisted music teaching influences their learning outcomes. Accordingly, this study uses the TAM framework to examine students' digital-technology adoption processes and usage patterns, while drawing on Constructivist Learning Theory to explain the pathways by which AI-supported learning supports students' educational outcomes.

## 2.2 Parent Disciplines

### 2.2.1 Technology Acceptance Model (TAM)

TAM, first proposed by Davis et al. (1989), is widely viewed as an important theoretical framework for explaining how people form perceptions of, accept, and use new technologies. Since its establishment, TAM has provided a systematic approach for examining users' technology-related decisions and explaining the factors that shape acceptance behaviors. Originally developed for understanding technology adoption in information systems, the Technology Acceptance Model has gradually gained broader application across different research areas, especially within educational settings.

Against the backdrop of digital transformation and the growing use of AI in learning environments, TAM offers useful explanations of how students assess and interact with AI-driven educational technologies. The model continues to serve as an effective theoretical foundation for exploring learners' cognitive perceptions, attitudinal responses, and intentions to use innovative learning systems.

According to TAM, whether individuals accept a technology is mainly influenced by their assessment of its usefulness and ease of operation. In this model, perceived usefulness and perceived ease of use are two key beliefs that shape users' attitudes toward technology and further affect their intention to use it. Perceived usefulness means that users believe a specific system can improve their performance, whereas perceived ease of use means that users believe the system can be operated with little effort (Davis et al., 1989). These belief-based judgments shape users' attitudes toward technology and may further influence their intention to adopt and sustain the use of such systems. The causal pathway proposed in TAM has been supported by empirical studies across different educational contexts. Nuryakin et al. (2023) reported that students' attitudes toward digital learning technologies are significantly affected by perceived usefulness and perceived ease of use. Similarly, Alshammari et al. (2025) showed that these two perceptions remain important predictors of learners' intention to use AI-based educational applications in learning environments. Overall, this evidence supports the use of TAM as an analytical framework for explaining how students perceive, accept, and engage with AI-supported learning contexts.

Apart from the two original TAM beliefs, perceived usefulness and perceived ease of use, recent studies have broadened this framework by adding contextual and behavioral variables to improve its explanatory power. In educational technology research, attitude, behavioral intention, facilitating conditions, and actual technology use are often included to better explain how learners accept and adopt technology. Within this expanded model, attitude refers to learners’ favorable or unfavorable views of technology use and functions as a key predictor of behavioral intention. Behavioral intention indicates users' willingness and future plans to engage with a technological system, whereas actual use represents the degree of practical interaction and application of the technology in real learning situations. Facilitating conditions refer to external factors such as technical infrastructure, institutional support, and training, which influence technology adoption. These extensions

enhance the applicability of TAM in complex educational environments. Feng et al. (2025) emphasized that support provided in learning environments is a key factor affecting students' choices to adopt educational technologies. Chai et al. (2021) found that learners' attitudes and technology-use intentions act as important pathways connecting their perceptions with actual technology engagement.

In recent years, TAM has been used more frequently in educational studies, especially in research related to AI and digital learning tools. Earlier studies have widely applied TAM to examine how learners respond to different technology-supported educational systems, such as online platforms, intelligent tutoring applications, and AI-based learning solutions. Jiang et al. (2025) used TAM to examine how university students adopt digital learning technologies and showed that perceived usefulness and perceived ease of use are important factors affecting learners' engagement and academic results. Similarly, Nurtanto et al. (2025) reported that TAM has strong explanatory ability in predicting users' intentions and technology-use behaviors.

Music education is a practice-oriented learning process that relies heavily on repeated training, timely guidance, and meaningful interaction. AI-supported music instruction can support personalized learning routes by providing adaptive assistance and timely responses to learners' needs, which may influence students' views of the usefulness and usability of such tools. Previous research has indicated that learners' acceptance of digital music learning applications plays an important role in determining their participation levels and learning effectiveness (Shan et al., 2025). Therefore, TAM offers an appropriate theoretical basis for analyzing students' acceptance of AI-assisted music teaching and its influence on learning results.

Several limitations remain. First, many studies focus primarily on technology acceptance rather than learning outcomes. Although TAM explains technology adoption behavior, it does not fully address how technology use influences educational effectiveness. Second, limited research has applied TAM specifically to artificial intelligence-assisted music education. Prior investigations have predominantly explored technology acceptance within broad educational settings, with relatively limited attention given to the characteristics of specific disciplines, such as music education. In addition, many studies have analyzed individual TAM-related factors separately, resulting in insufficient understanding of how these variables collectively contribute to students' learning

achievements. Therefore, further empirical research is required to establish an integrated framework that connects technology acceptance processes with educational outcomes.

To address these identified gaps, this study uses TAM as the main theoretical lens to examine university students' perceptions of and engagement with AI-supported music instruction, as well as the relationship between acceptance processes and learning outcomes. By incorporating contextual and behavioral variables, including facilitating conditions, perceived usefulness, perceived ease of use, attitude, behavioral intention, and actual technology use, the study broadens the conventional TAM framework and offers a fuller explanation of learning effectiveness in AI-enhanced music education. In addition, TAM is combined with constructivist learning theory to clarify how AI-assisted music teaching affects students' learning outcomes. This integrated theoretical approach supports the research questions and offers a solid basis for analyzing students' acceptance and learning outcomes in AI-assisted music teaching.

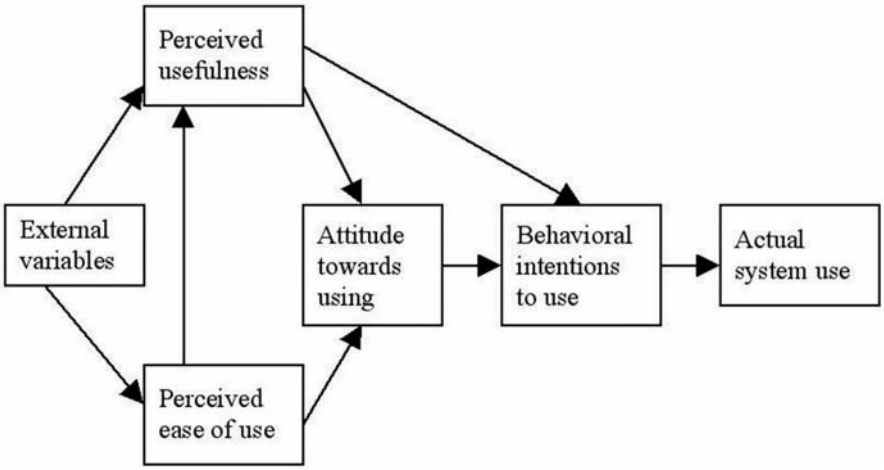



**Figure 2. 1** Technology Acceptance Model
**Source:** Davis et al. (1989)

### 2.2.2 Constructivist Learning Theory

Constructivist learning theory is commonly regarded as a major educational perspective for explaining how learners develop knowledge through active interaction, personal experience, and reflection. This theory argues that learning is not a one-way transfer of knowledge from teachers to students, but an active meaning-making process in

which learners form understanding on the basis of their existing knowledge and experiences (Do et al., 2023). From this view, learners occupy a central position in knowledge construction, and their learning outcomes are affected by engagement, participation, and interaction in the learning environment. In recent years, constructivist learning theory has been more frequently used in technology-supported learning contexts, especially in digital and AI-supported environments where learners are guided to explore knowledge actively and strengthen problem-solving abilities (Md Zin et al., 2024). These developments indicate that constructivist learning theory offers an appropriate theoretical basis for explaining learning processes in AI-assisted music teaching.

From a constructivist perspective, effective learning is understood as a dynamic process involving learners' active participation, social interaction, meaningful contexts, and independent knowledge construction. Active learning is considered a core principle of constructivist learning, as learners actively engage with learning materials and construct knowledge through exploration and reflection (Doolittle et al., 2023). Active learning settings can strengthen students' participation and academic achievement, especially when they are supported by educational technologies. In addition, collaborative learning represents another key element of constructivist learning theory. Social interaction is essential for knowledge construction because students build understanding through dialogue and cooperation with classmates and teachers (Huang & Lajoie, 2023). Recent studies indicate that collaborative learning environments supported by digital technologies improve students’ engagement and learning outcomes (Srivastava, 2025).

Constructivist learning theory also emphasizes contextual learning, which refers to learning in authentic environments that reflect real-world experiences. Contextual learning helps students apply knowledge in practical situations and develop meaningful understanding (Utami et al., 2023). In music education, contextual learning is particularly important because students need to practice skills and apply theoretical knowledge in real performance situations. AI-enhanced music instruction creates more meaningful learning contexts by enabling immediate performance feedback and personalized instructional adjustments based on students’ individual learning needs. Technology-supported contextual learning improves students’ performance and learning outcomes (Merchán Sánchez-Jara et al., 2024). Therefore, constructivist learning theory is appropriate for explaining learning processes in AI-assisted music education.

Learner autonomy is also a core feature of constructivist learning theory. Constructivist learning contexts encourage students to manage their own learning and participate in independent learning activities (Do et al., 2023). Independent learning can strengthen students' motivation and academic performance in digital learning contexts (Rini et al., 2022). Artificial intelligence technologies support learner autonomy by providing personalized learning pathways and adaptive feedback. These functions are consistent with constructivist learning principles and may contribute to better learning results.

Artificial intelligence-supported learning environments provide interactive learning experiences, personalized feedback, and adaptive learning content, which align with constructivist learning principles (Mohd Amin et al., 2025). AI-supported learning contexts can increase students' participation and lead to better learning results (Wang et al., 2024). AI-based technologies support learners in engaging in self-directed practice, obtaining immediate guidance on their performance, and enhancing their creative abilities through interactive learning processes. These features support constructivist learning environments and promote knowledge construction.

Despite its advantages, constructivist learning theory also has limitations. Constructivist learning environments require sufficient technological infrastructure and instructional support. Without appropriate support, students may experience difficulties in self-directed learning (Tsehay et al., 2024). Additionally, some students may struggle with autonomous learning environments, which may reduce learning effectiveness (Cullen & Oppenheimer, 2024). These limitations suggest that constructivist learning environments require supportive conditions and technology acceptance to improve learning outcomes.

For this research, constructivist learning theory explains how AI-supported music teaching facilitates students' active participation, collaborative learning, and personalized learning. AI-supported music teaching offers adaptive learning settings and timely feedback, which are consistent with constructivist learning principles. Through the combination of constructivist learning theory and TAM, the study develops an integrated framework for analyzing students' learning outcomes in AI-assisted music teaching. This theoretical combination helps address the research questions and reinforces the theoretical basis of the present study.

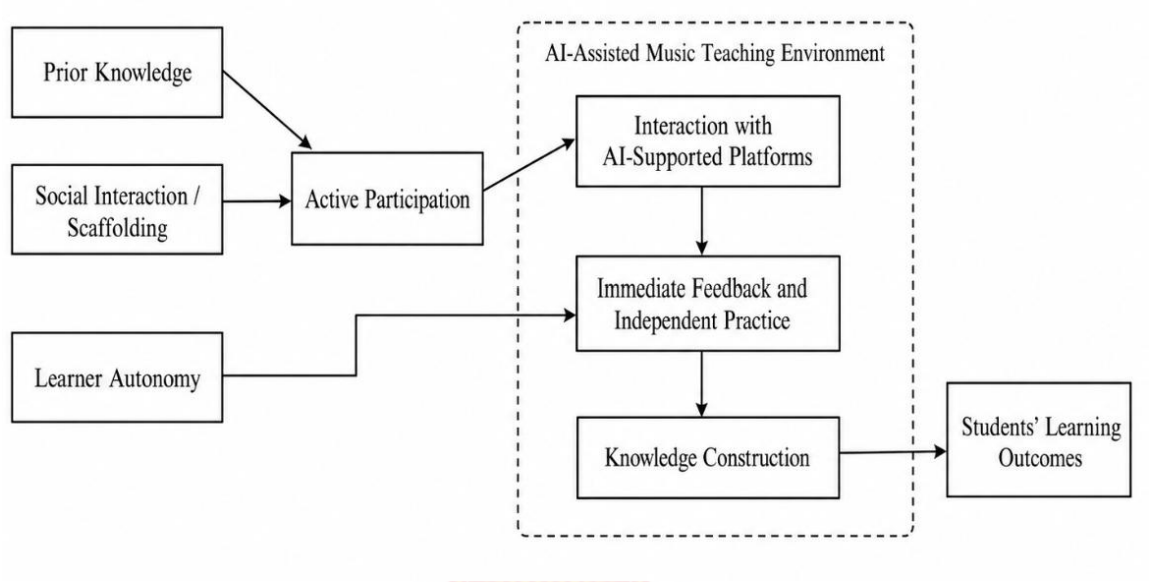



**Figure 2. 2** Constructivist Learning Theory Model

**Source:** Piaget (1970), Vygotsky (1978), and Do et al. (2023)

## 2.3 Immediate Disciplines

### 2.3.1 Facilitating Conditions

Facilitating conditions refer to users' views of whether institutional resources, technical assistance, and essential infrastructure are available to support effective technology use. This construct has been frequently integrated into extended TAM models because it provides additional insight into the factors that facilitate successful technology adoption and continued use (Venkatesh et al., 2003). This construct in TAM explains how external environmental factors influence users' perceptions and technology adoption behavior, particularly in educational technology and artificial intelligence contexts. Within educational contexts, facilitating conditions are viewed as external supports, including access to necessary resources, organizational assistance, and technological infrastructure, that help learners engage with digital tools more effectively. This construct extends the explanatory scope of TAM by incorporating environmental factors beyond users' internal perceptions and cognitive evaluations (Fokides & Daskalou, 2026). Therefore, facilitating conditions are often incorporated into TAM-related studies to better explain technology acceptance behavior in complex learning environments.

Facilitating conditions are typically measured from several aspects, including technological infrastructure, technical support, and training opportunities. Technological infrastructure encompasses the availability of digital devices, reliable network connections, and appropriate software systems that provide the foundation for effective technology integration in online and technology-enhanced learning contexts (Haleem et al., 2022). Technical support refers to the availability of assistance when users encounter difficulties while using technology, which improves users' confidence and adoption behavior (Caratiquit & Caratiquit, 2022). Training opportunities refer to the provision of guidance and instruction that helps users develop skills needed to use technology effectively, which enhances users' readiness to adopt educational technologies (Mhlongo et al., 2023). These measurement dimensions indicate that facilitating conditions reflect the overall environment supporting technology adoption in educational settings.

Recent studies in educational technology and artificial intelligence contexts highlight the importance of facilitating conditions. Sufficient facilitating conditions improve users' perceptions and encourage adoption behavior in digital learning environments (Feng et al., 2025). Stumbrienė et al. (2023) indicated that adequate support resources and technological conditions enhance teachers' willingness to implement digital learning technologies. Similarly, Muyambi and Ramorola (2025) emphasized that institutional support and accessible technological resources help strengthen educators' confidence and ability to incorporate technology into instructional practice. In AI-based educational settings, supportive conditions can positively influence users' acceptance and use of AI applications. Taken together, these studies show that external support is essential for facilitating effective technology integration within education (Taheri et al., 2025).

Facilitating conditions are particularly important in artificial intelligence-assisted learning environments because AI-based systems often require specific technical support and infrastructure (Taheri et al., 2025). Moreover, facilitating conditions serve as important external factors that shape learners' participation and academic performance within technology-supported learning contexts (Wang et al., 2024). These findings further demonstrate that adequate technical resources and supportive learning environments are essential for promoting effective engagement with AI-based educational systems.

In the context of music education, facilitating conditions become especially important because artificial intelligence-assisted music teaching often requires specialized equipment, digital tools, and technical support. Students may need access to AI-supported music learning platforms, digital instruments, and stable internet connectivity to effectively use AI-assisted music learning systems (Xu, 2026). Furthermore, teacher and institutional support has been regarded as a key element influencing students' intention to participate in AI-supported learning activities (Tan et al., 2025). Supportive conditions may contribute to students' willingness to adopt and utilize AI-enhanced music instruction. However, existing research on facilitating conditions has largely examined technology acceptance in broad educational contexts, while limited attention has been given to their role in discipline-specific areas such as AI-supported music education.

Limited research has examined facilitating conditions in relation to students' learning outcomes. Most studies focus on behavioral intention and technology adoption, while fewer studies explore how facilitating conditions influence learning outcomes through technology use (Llacuna et al., 2026). These research gaps indicate the need for further investigation into facilitating conditions in AI-assisted music teaching contexts.

Therefore, this study treats facilitating conditions as an external antecedent that may affect students' acceptance of AI-assisted music teaching. By examining how this support-related construct relates to perceived ease of use and perceived usefulness, the study further extends TAM and offers a fuller explanation of students' learning outcomes. Including this construct also clarifies how external support shapes students' perceptions and technology use in AI-assisted music teaching settings. For this reason, facilitating conditions are retained as a key variable in the present model.

**2.3.2 Perceived Ease of Use**

Perceived ease of use describes the extent to which users believe that operating a specific system can be completed with little effort (Davis et al., 1989). In the TAM framework, this perception affects perceived usefulness and users' attitudes toward adopting technology, and is therefore viewed as an important predictor of technology acceptance behavior (Venkatesh & Davis, 2000). Recent studies still show that perceived ease of use is a critical factor affecting users' acceptance of educational technologies, especially in AI-assisted learning contexts (Feng et al., 2025). Therefore, perceived ease of use is commonly used in educational technology studies to explain learners' acceptance of new technologies.

Perceived ease of use generally describes users' views about whether a technological system is simple, usable, and accessible. In educational contexts, this construct indicates whether learners consider a system understandable, operable, and suitable for inclusion in their learning activities (Dou & Feng, 2025). When learners regard a system as simple to operate, they tend to form more favorable attitudes toward it and show stronger readiness to accept it. By contrast, if learners view a technology as hard to operate, they may feel frustrated, which may weaken their intention to use it (Al-Adwan et al., 2023). Therefore, perceived ease of use is viewed as a key factor affecting technology acceptance and learning-related behavior.

Perceived ease of use is typically measured through several aspects, including system usability, clarity of interface, ease of learning, and operational simplicity. These dimensions reflect whether users can easily understand and use a technology system without extensive training. In recent research, scholars have also included additional dimensions such as accessibility, user-friendly interface, and interaction efficiency when measuring perceived ease of use (Rajapakshe et al., 2026). Taken together, these measurement methods show that this construct captures users' general judgments about how usable a technology is.

Empirical evidence from educational technology studies suggests that learners' perceptions of system simplicity and usability are closely associated with their acceptance of digital learning applications. Linus et al. (2025)reported that students' judgments about operational simplicity had a significant effect on their readiness to use digital learning platforms in university settings. Similarly, Songkram et al. (2023) showed that favorable usability perceptions were associated with more positive attitudes and stronger intentions to adopt technology. Moreover, perceived ease of use has been identified as an important predictor of students' acceptance of AI-supported learning systems (Osman, 2025). Taken together, these studies emphasize that usability-related perceptions are important for explaining learners' technology adoption behaviors in educational settings.

When learners experience difficulties in understanding or operating AI-based tools, they may reduce their engagement with these technologies and fail to obtain their potential educational benefits (Thomson et al., 2024). In contrast, AI applications that are easy to access and operate can motivate students to take part in learning more actively, thereby improving their learning experiences and academic achievement (Villaver & Cabigas,

2025). Therefore, perceived ease of use functions as an important psychological factor influencing the effective application of AI-supported learning settings.

Within music education settings, perceived ease of use is especially important because AI-assisted music teaching usually requires students to work with specialized software and digital learning platforms. Learners may interact with AI-supported music learning systems, digital instruments, and intelligent feedback tools. If these systems are simple to operate, students tend to accept them more readily and participate in learning activities. Conversely, overly complicated systems may prevent students from using AI-assisted music teaching tools. Therefore, perceived ease of use is a key factor affecting students' acceptance of AI-assisted music teaching.

Accordingly, this construct is added to the model to reflect students' evaluations of the usability of AI-assisted music teaching. The analysis examines how such usability judgments affect perceived usefulness and students' attitudes toward AI-based instruction. In this way, TAM is used to explain not only acceptance intention, but also whether students' experience of system simplicity contributes to learning-related outcomes.

**2.3.3 Perceived Usefulness**

Perceived usefulness (PU) refers to users' belief that a technological system can enhance their task effectiveness and overall performance. As a key construct in TAM, it explains how individuals assess the practical benefits of a technology and how these assessments affect later adoption decisions (Davis et al., 1989). Although TAM was first developed in information systems research, perceived usefulness has been widely applied in educational studies to explain learners' acceptance of digital and AI-supported learning technologies. Recent empirical findings also show that perceived usefulness remains an important predictor of technology adoption in modern educational settings (Gupta et al., 2026).

Perceived usefulness generally reflects learners' beliefs regarding whether technology improves learning efficiency, enhances learning performance, and supports academic achievement. In educational contexts, perceived usefulness often refers to whether students believe that using technology improves their learning effectiveness, increases productivity, and enhances learning outcomes (Toros et al., 2024). Perceived usefulness is typically measured through several aspects, including performance improvement, learning effectiveness, productivity enhancement, and academic achievement (Dou & Feng, 2025).

These dimensions reflect whether technology helps users achieve their learning goals more efficiently. Recent studies also incorporate indicators such as learning efficiency, knowledge acquisition, and skill development when measuring perceived usefulness in digital learning environments (Vaszkun & Mihalkov Szakács, 2025). These measurement approaches indicate that perceived usefulness reflects learners' perceptions of technology benefits. Chen et al. (2025) found that students' judgments of technology value had a significant effect on their acceptance of digital learning platforms in universities. Similarly, Songkram et al. (2023) reported that favorable views of usefulness were associated with more positive attitudes and stronger intentions to adopt educational technologies. Perceived benefit is an important factor predicting students' acceptance of AI-supported learning applications (Zhao et al., 2025). Taken together, these studies suggest that learners' judgments of technological value help explain adoption behavior in educational contexts.

Perceived usefulness is particularly relevant because artificial intelligence-assisted music teaching provides personalized feedback, adaptive learning content, and real-time evaluation (Dou & Feng, 2025). These features may improve students' learning performance and engagement. Students tend to use digital music learning tools when they believe these tools can help improve their learning results (Shan et al., 2025). In addition, artificial intelligence technologies can enhance music learning by providing individualized instruction and performance feedback, which improves learning effectiveness (Ou et al., 2025). Therefore, this study analyzes how perceived usefulness affects attitude, behavioral intention, and learning outcomes, thereby broadening TAM and offering a fuller explanation of students' learning results. Including this construct helps clarify how students’ judgments of technological benefits shape their acceptance of AI-assisted music teaching. As a result, perceived usefulness is retained as a key variable in the present study.

**2.3.4 Attitude toward AI-assisted music teaching (AIT)**

Attitude toward AI-assisted music teaching represents students’ favorable or unfavorable perceptions of incorporating artificial intelligence technologies into music learning activities. Based on TAM, attitude is viewed as an important psychological factor that explains how users assess technologies and develop intentions to accept them (Davis et al., 1989). In this model, individuals' attitudes are shaped by their judgments of technological usefulness and usability, especially perceived usefulness and perceived ease

of use. Such judgments further influence their readiness to participate in and keep using technology-supported learning systems (Venkatesh & Davis, 2000). Therefore, attitude is an important construct for explaining students' acceptance and use of AI-supported music learning technologies.

In educational contexts, attitude is often conceptualized as learners' emotional and cognitive evaluation of using technology in learning activities (Dou & Feng, 2025). In contrast, unfavorable evaluations may weaken their readiness to rely on AI tools, even if they are aware that these tools may offer learning advantages. Attitude toward AI-assisted music teaching is typically measured through several aspects, including perceived enjoyment, perceived value, and overall evaluation of technology use. These dimensions reflect students' emotional responses and perceptions toward using artificial intelligence in music learning.

Bervell et al. (2025) reported that students' views of digital learning tools had a significant effect on their intention to use them. Similarly, Feng et al. (2025) reported that learners' positive views of educational technology promoted their adoption behavior. Students' attitudes toward AI-based learning tools strongly affected their readiness to accept such technologies (Sultana et al., 2025). Attitude toward AI-assisted music teaching is particularly important in music education because music learning often involves creativity, engagement, and emotional involvement. Artificial intelligence-assisted music teaching provides interactive learning environments, personalized feedback, and adaptive learning experiences, which may influence students' attitudes toward learning (Tan et al., 2025). If students perceive AI-assisted music teaching as complicated or less helpful, they may develop negative attitudes, which can reduce adoption behavior.

Therefore, this study incorporates attitude toward AI-assisted music teaching as an important variable in the research model. The inclusion of attitude toward AI-assisted music teaching helps explain students' emotional responses and perceptions toward artificial intelligence-assisted learning. Consequently, attitude toward AI-assisted music teaching is considered an important variable in this study.

**2.3.5 Intention to use AI-assisted music teaching (BI)**

Behavioral intention to use AI-assisted music teaching refers to students' expected readiness and commitment to apply AI technologies in their music learning process. From the perspective of TAM, behavioral intention reflects a person' s mental preparedness

to carry out a particular technology-related behavior and functions as a direct predictor of actual system use (Davis et al., 1989). Within this framework, users' intentions are formed through their judgments of technological usefulness, operational ease, and general attitudes toward the technology (Venkatesh & Davis, 2000). Prior educational technology studies have repeatedly shown that behavioral intention strongly predicts learners' real engagement with digital learning systems (Nurtanto et al., 2025). Therefore, examining students' intention to use AI-assisted music teaching is necessary for understanding how AI technologies are accepted and incorporated into music education.

In educational environments, behavioral intention reflects learners' future-oriented decisions regarding technology adoption, including their willingness to initiate use, maintain continuous interaction, and recommend the technology to other users (Dou & Feng, 2025). Existing research has operationalized behavioral intention through multiple dimensions, such as the willingness to use technology, plans for continued utilization, and intention to recommend the system to others (Ayanwale & Ndlovu, 2024). These dimensions reflect users' commitment to adopting technology in the future. Recent studies also include indicators such as intention to recommend and intention to explore advanced features of technology (Tseng, 2025). These measurement approaches indicate that behavioral intention reflects users' future usage plans.

Recent research in educational technology contexts has demonstrated that behavioral intention significantly influences learners' adoption of digital learning technologies. Songkram et al. (2023) found that behavioral intention significantly influenced students' use of digital learning platforms in higher education. Similarly, Tahir (2023) reported that behavioral intention positively influenced students' adoption of educational technologies. In addition, studies on AI-assisted learning settings show that behavioral intention has a notable effect on students' uptake of AI-based learning systems (Wu et al., 2022).

Behavioral intention is particularly important in artificial intelligence-assisted music teaching because AI-based learning systems often require students to actively engage with learning tools. Conversely, when students show low intention to use AI-assisted music teaching, they may avoid using such systems, which limits learning effectiveness. Therefore, behavioral intention plays an important role in AI-assisted music teaching environments. Most research has examined adoption behavior itself, whereas

limited work has analyzed whether behavioral intention affects learning results through actual use (Peng & Yan, 2022). These research gaps highlight the need for further investigation into behavioral intention in AI-assisted music teaching contexts.

Accordingly, students' intention to use AI-assisted music teaching is included in the model to capture the motivational stage before actual usage occurs. This study examines how perceived usefulness and attitude shape students' intention, and how such intention is translated into actual engagement with AI-assisted music teaching. Through this arrangement, the TAM framework is applied beyond simple acceptance judgment and is used to explain the process from perception formation to technology use. In this sense, intention to use AI-assisted music teaching helps clarify why students may decide to adopt AI-based music learning tools and how this decision contributes to subsequent usage behavior.

**2.3.6 Use AI-assisted music teaching (AU)**

From the TAM perspective, students' actual use of AI-supported learning technologies mainly depends on behavioral intention; this intention reflects their motivation and preparedness to use technology in learning settings (Davis et al., 1989). Recent studies in educational technology confirm that behavioral intention significantly predicts actual technology use in learning environments, and this relationship has been widely validated in artificial intelligence-assisted learning contexts (Yang et al., 2025).

Actual use generally refers to the frequency, duration, and extent of users' interaction with a technology system. In educational contexts, actual use reflects how often students use learning technologies, how actively they engage with learning tools, and how consistently they participate in technology-supported learning activities (Joshi et al., 2025). Conversely, limited use may reduce the effectiveness of technology integration, even when students demonstrate positive attitudes or intentions (Mustofa et al., 2025). Therefore, actual use is considered an important variable linking technology acceptance to learning outcomes.

Actual use is typically measured through several aspects, including usage frequency, duration of use, and level of engagement. These dimensions reflect how actively users interact with the technology system. Recent research also incorporates indicators such as level of interaction, number of learning activities completed, and consistency of usage when measuring actual use in digital learning environments (Uzorka & Odebiyi, 2025).

These measurement approaches indicate that actual use reflects users' engagement with learning technologies.

Joshi et al. (2025) reported that learners who made active use of online learning platforms achieved better academic performance. Similarly, Kusumo et al. (2024) stated that the actual use of educational technologies had a significant effect on students' learning engagement and achievement. In addition, studies on AI-assisted learning settings suggest that students' practical use of AI-driven learning systems can significantly improve learning results (Alam et al., 2026). Actual use is particularly important in artificial intelligence-assisted music teaching because music learning requires consistent practice and interaction. Artificial intelligence-assisted music teaching provides real-time feedback, adaptive learning pathways, and personalized instruction, which require students to actively engage with learning systems. Conversely, limited use of AI-assisted music teaching tools may reduce learning effectiveness. Therefore, actual use plays an important role in AI-assisted music.

Despite the importance of actual use, previous studies have primarily focused on technology adoption rather than actual use in music education contexts. Most previous studies focus on behavioral intention, while fewer studies explore how actual use influences learning outcomes (Songkram et al., 2023). Therefore, these limitations call for additional research on actual use within AI-assisted music teaching settings.

Therefore, this study incorporates use of AI-assisted music teaching as an important variable in the research model. The inclusion of actual use helps explain how students' engagement with AI-assisted music teaching influences learning outcomes. Consequently, use of AI-assisted music teaching is considered an important variable in this study.

**2.3.7 Students' Learning Outcomes (LO)**

Students' learning outcomes refer to the knowledge, skills, abilities, and attitudes gained through participation in educational activities. This concept is closely connected with constructivist perspectives, which argue that learning results are formed through active meaning-making and meaningful learning experiences. According to constructivism, learners build knowledge through interaction, personal experience, and reflection, and this process can promote cognitive development and improve learning performance (Yakubu et al., 2025). In recent educational studies, learning outcomes are often analyzed as

products of student-centered learning settings, which correspond to constructivist learning principles (Eom et al., 2006). Therefore, students' learning outcomes are considered a key dependent variable in studies grounded in constructivist learning theory.

From a constructivist perspective, learning outcomes are achieved when students actively engage in learning activities and construct knowledge through experience. Constructivist learning environments encourage learners to explore, collaborate, and reflect, which improves understanding and learning performance (Closs et al., 2022). Constructivist learning approaches significantly improve students' cognitive abilities, and academic performance (Tsai et al., 2023).

Students' learning outcomes are generally measured from several dimensions, including cognitive outcomes, skill development, and affective outcomes. Cognitive outcomes refer to knowledge acquisition and conceptual understanding, while skill development refers to learners' ability to apply knowledge in practice (Cherukunnath & Singh, 2022). Affective outcomes include learning motivation, engagement, and attitudes toward learning (Liu et al., 2024). These dimensions reflect the comprehensive nature of learning outcomes in constructivist learning environments. Research also indicates that constructivist learning improves critical thinking, creativity, and collaboration, which are considered important indicators of learning outcomes (Wiyono et al., 2025).

Recent studies have also examined students' learning outcomes in artificial intelligence-assisted learning environments. Artificial intelligence technologies support personalized learning, adaptive feedback, and interactive learning environments, which align with constructivist learning principles and improve learning outcomes (Mohd Amin et al., 2025). AI-assisted learning enhances students' engagement, learning efficiency, and academic performance, which are key indicators of learning outcomes (Alam et al., 2026). Moreover, AI-enabled learning settings can strengthen students' learning autonomy and academic performance by offering individualized learning routes (Farhood et al., 2025).

In music education contexts, students' learning outcomes are particularly important because music learning requires skill development, creativity, and continuous practice. AI-assisted music teaching offers instant feedback, individualized learning routes, and adaptive instructional systems, thereby supporting better student learning outcomes. Recent studies show that AI-supported music learning strengthens learners' technical competence, participation, and learning confidence (Wu & Qin, 2025). Furthermore,

artificial intelligence-assisted music education enhances creativity and self-directed learning, which are key indicators of learning outcomes in constructivist learning environments (Merchán Sánchez-Jara et al., 2024). Despite the growing interest in students' learning outcomes in artificial intelligence-assisted learning environments, previous studies have primarily focused on general education contexts rather than music education. In addition, limited research has examined students' learning outcomes within AI-assisted music teaching using constructivist learning theory. Most studies focus on technology adoption or engagement, while fewer studies examine learning outcomes as the final result of AI-assisted learning (Alam et al., 2026).

Therefore, this study incorporates students' learning outcomes as the dependent variable, grounded in constructivist learning theory. The inclusion of students' learning outcomes helps explain the effectiveness of AI-assisted music teaching and provides a theoretical foundation for improving music education practices.

## 2.4 Theoretical Framework and Hypothesis development

### 2.4.1 Conceptual Framework

Figure 2.3 illustrates the conceptual model developed for the present study. This model combines the technology acceptance view of TAM with the learner-centered perspective of Constructivist Learning Theory, aiming to clarify how AI-supported music instruction may influence students' learning results. In this model, learning results are understood as outcomes of students' cognitive judgments, acceptance choices, and behavioral participation in AI-supported music learning. The model includes seven constructs: facilitating support, perceived usability, perceived benefit, attitude toward AI-supported music instruction, intention to use it, actual use, and student learning results.

Facilitating conditions represent the contextual and environmental support available for students' interaction with AI-assisted music teaching systems. In this study, this construct encompasses technological infrastructure, institutional support, and accessible learning resources that facilitate effective technology utilization. Sufficient support conditions can lower technological barriers and improve learners' judgments of the operability and learning benefits of AI-supported music instruction. Accordingly, facilitating conditions are hypothesized to positively affect perceived ease of use (H1) and perceived usefulness (H2). This pattern suggests that learners' evaluations of AI-enabled

music learning are shaped not solely by technical features but also by the broader educational context.

In TAM, ease perception and perceived utility function as core belief factors. Ease perception concerns students' appraisal of whether AI-assisted music teaching systems are simple, accessible, and convenient to operate, whereas perceived utility refers to their belief that such technologies can improve learning efficiency and musical development. Following TAM logic, ease perception is hypothesized to have a positive effect on perceived utility (H3), since tools that demand lower cognitive effort tend to be judged as more valuable for learning. In addition, these two perceptions are expected to foster students' positive attitudes toward AI-assisted music teaching (H4 and H5). Students who regard AI-supported music learning as convenient and beneficial tend to develop favorable attitudes toward adopting it.

Attitude toward AI-assisted music teaching refers to students' overall psychological evaluation of using AI technologies in music learning contexts. Favorable attitudes are expected to increase learners' readiness to participate in AI-supported learning systems. Accordingly, attitude toward AI-assisted music teaching is hypothesized to positively predict intention to use AI-assisted music teaching (H7). Meanwhile, perceived usefulness is also expected to directly promote students' intention to use AI-assisted music teaching (H6), because learners who perceive stronger learning benefits tend to consider adopting such technologies.

Intention to use AI-assisted music teaching reflects students' future-oriented inclination and preparedness to apply AI tools in their learning process. Following the TAM framework, stronger behavioral intentions are expected to result in greater actual interaction with AI-supported music learning technologies. Therefore, intention to use AI-assisted music teaching is proposed to positively influence actual use of AI-assisted music teaching (H8). Actual use represents students' practical involvement with AI technologies during music learning activities. From the perspective of Constructivist Learning Theory, meaningful engagement and active participation are essential processes through which learners construct knowledge and develop skills. Accordingly, students' actual engagement with AI-assisted music teaching is hypothesized to have a positive effect on their learning outcomes (H9).

Furthermore, perceived usefulness is hypothesized to directly influence students' learning outcomes (H10). This relationship reflects the assumption that when students perceive artificial intelligence-assisted music teaching as beneficial, they are more likely to achieve improved learning outcomes.

Overall, the conceptual framework establishes a structured relationship in which facilitating conditions influence students' perceptions, perceptions shape attitudes and intention, intention leads to actual use, and actual use ultimately influences students' learning outcomes. Through the combination of TAM and Constructivist Learning Theory, this framework offers an integrated explanation of how AI-assisted music teaching affects students' learning outcomes.

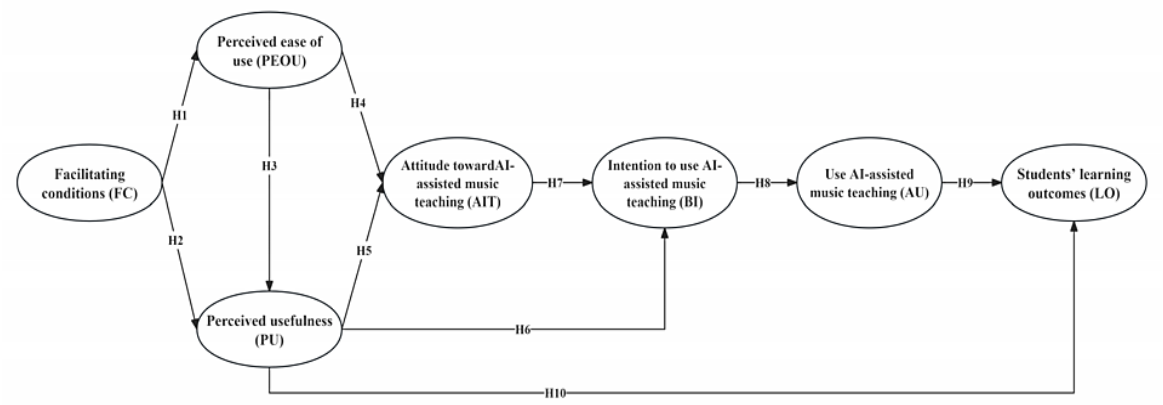



**Figure 2. 3** Conceptual framework

### 2.4.2 Hypothesis Development

Within the expanded TAM framework, facilitating conditions function as an external environmental antecedent that shapes learners' perceptions and evaluations of technology adoption (Fokides & Daskalou, 2026). Supportive conditions can make AI-supported learning resources less complex and strengthen students' confidence when using such systems (Monazam-Tabrizi et al., 2026). Earlier studies have verified the link between external support conditions and perceived usability. In technology-assisted language learning settings, sufficient external assistance was found to improve learners' views of system usability by lowering technical obstacles and enhancing users' sense of control (Ebadi & Raygan, 2023b). Similarly, research on AI adoption among university students indicated that institutional support and available resources contribute to easier interaction with unfamiliar digital technologies (Xia & Guo, 2025). Moreover, supportive

educational environments have been shown to strengthen users' technology-related practices, suggesting that contextual conditions provide an essential foundation for developing positive usability perceptions (Katsimpelis et al., 2026). Therefore, the following hypothesis is proposed:

H1: Facilitating conditions positively influence perceived ease of use.

Perceived usefulness reflects students' beliefs regarding whether a technological system can enhance learning efficiency, improve performance, and provide valuable support during learning activities. Within the TAM framework, perceived usefulness represents a critical cognitive evaluation that determines users' acceptance of emerging technologies (Venkatesh & Davis, 2000). Facilitating conditions may contribute to the formation of perceived usefulness because sufficient technical infrastructure, organizational support, and instructional assistance allow learners to experience the practical advantages of AI-assisted music teaching more effectively (Jiang et al., 2025). Cabellos et al. (2024) reported that facilitating conditions significantly influenced users' perceptions of technology usefulness in educational settings, particularly when institutional support improved users' access to digital learning systems. Similarly, Abulail et al. (2025) found that facilitating conditions positively influenced perceived usefulness in artificial intelligence adoption contexts, suggesting that external support enables users to recognize the benefits of technology. In addition, Ebadi and Raygan (2023b) indicated that facilitating conditions improved learners' perceptions of usefulness by reducing technical barriers and enhancing learning efficiency. Furthermore, recent research in artificial intelligence-assisted learning environments also supports this relationship. Previous studies indicate that support conditions, including technical assistance, system access, and training provision, can improve learners' views of AI-supported learning systems and strengthen their perceived usefulness (Sustaningrum & Haldaka, 2025). In addition, learners with adequate support are more inclined to view technology as helpful for enhancing learning performance (Feng et al., 2025). Therefore, this study proposes the following hypothesis:

H2: Facilitating conditions positively influence perceived usefulness.

Ease perception describes students' belief that AI-assisted music teaching can be operated with little effort, whereas perceived utility captures their view that this teaching approach can improve their learning performance (Dou & Feng, 2025). Both constructs

are derived from TAM, which assumes that ease perception affects perceived utility because systems with simpler operation tend to be viewed as helpful for performance improvement (Venkatesh & Davis, 2000). Ease perception has a significant effect on perceived utility in AI-supported learning settings, showing that systems with user-friendly design can strengthen learners' perceived benefits and adoption intentions (Razzouki et al., 2025). Similarly, studies on AI adoption in education reported that ease perception promotes technology adoption indirectly by increasing perceived utility, because smooth interaction helps users recognize the functional value of AI-based learning systems more clearly (Zhao et al., 2025). Furthermore, empirical work on students' AI adoption found that technologies viewed as simple to operate can improve learners' sense of learning effectiveness and educational value, thereby reinforcing perceived utility (Singh et al., 2026). Therefore, this study proposes the following hypothesis:

H3: Perceived ease of use positively influences perceived usefulness.

Ease perception describes students' belief that AI-assisted music teaching can be used with little effort. This construct is derived from TAM, which suggests that perceived usability can shape users' attitudes toward adopting technology (Davis et al., 1989). Within educational contexts, perceived usability serves as a key factor affecting learners' views of emerging technologies (Maričić et al., 2025). When students find learning systems easy to use, they experience less cognitive burden and greater confidence in using the technology, which contributes to positive attitudes. Conversely, systems that are complicated to operate can cause learner frustration and weaken motivation, resulting in unfavorable views of technology adoption (Novak et al., 2023). Thus, perceived usability can be viewed as a key antecedent of learners' attitudes toward educational technologies. Evidence from digital learning settings further shows that ease perception has a significant effect on learners' views of learning platforms and other instructional technologies (Noor et al., 2022). Therefore, this study puts forward the following hypothesis:

H4: Perceived ease of use positively influences attitude toward AI-assisted music teaching.

Perceived utility describes students’ belief that AI-assisted music teaching can improve their learning performance. This construct is derived from TAM, which suggests that perceived utility can shape users' attitudes toward adopting technology (Davis et al., 1989). Conversely, when students perceive limited benefits from technology use, they may

develop negative attitudes toward adoption. Studies on learners' acceptance of AI-based learning systems showed that perceived utility had a strong effect on their attitudes toward AI adoption (Liang & Reiss, 2025). Similarly, research on digital learning platforms reported that perceived benefit promoted learners' favorable views of technology use and their learning participation (Brugliera, 2024). In addition, evidence from AI-supported learning settings showed that usefulness perceptions shaped students' positive evaluations of AI-assisted learning systems (Wu et al., 2022). Therefore, this study puts forward the following hypothesis:

H5: Perceived usefulness positively influences attitude toward AI-assisted music teaching.

As a core element of TAM, perceived usefulness captures users' judgments about whether a technology has practical value and can support task performance (Davis et al., 1989). Studies on AI-supported learning settings have shown that learners who recognize the educational value of AI applications usually display stronger intentions to use such tools (Otto et al., 2024). Similarly, Gong and Mao (2026) reported that perceived utility positively promoted learners' readiness to adopt technology-based learning solutions. Students' judgments of technological usefulness also had a significant effect on their intention to take part in technology-enhanced learning activities. Taken together, these studies suggest that perceived utility is a key mechanism explaining students' decisions to accept and use AI-supported educational technologies (Zhang et al., 2024). Therefore, this study puts forward the following hypothesis:

H6: Perceived usefulness positively influences intention to use AI-assisted music teaching.

Attitude toward AI-assisted music teaching denotes students' general favorable or unfavorable appraisal of applying AI tools in music learning. In TAM, attitude toward use is treated as a central antecedent of behavioral intention (Davis et al., 1989). In educational contexts, learners' views of technology strongly shape their intention to adopt learning systems. Students with favorable evaluations of educational technologies tend to show greater readiness to use and participate in learning tools, whereas unfavorable evaluations may weaken use intention, even when the system is regarded as useful or simple to operate (Abdul Hasim & Bakar, 2025). Research on students' acceptance of AI technologies also found that positive AI-related attitudes strongly affected their intention to use AI-supported

learning systems (Liang & Reiss, 2025). Accordingly, this study proposes the following hypothesis:

H7: Attitude toward AI-assisted music teaching positively influences intention to use AI-assisted music teaching.

Both constructs are derived from TAM, in which behavioral intention is viewed as the closest predictor of actual system use (Davis et al., 1989). Conversely, low intention to use technology may lead to limited engagement, even when learning technologies are available. Therefore, behavioral intention is considered an important predictor of actual technology use. Research examining students' adoption of AI-supported learning systems found that behavioral intention significantly influenced actual use of artificial intelligence technologies (Alshammari et al., 2025). Similarly, Feng et al. (2025) reported that learners' willingness to adopt instructional technologies meaningfully predicted their actual use behavior. In addition, behavioral intention positively influenced students' actual engagement with learning platforms (Hayadi & Hariguna, 2025). These findings indicate that intention to use technology plays an important role in determining actual use behavior. Accordingly, the following hypothesis is proposed:

H8: Intention to use AI-assisted music teaching positively influences use of AI-assisted music teaching.

Use of AI-assisted music teaching refers to the extent to which students actively engage with artificial intelligence technologies during music learning activities, while students' learning outcomes refer to the knowledge, skills, and learning performance achieved through the learning process (Yang et al., 2025). This relationship is supported by constructivist perspectives, which argue that meaningful learning develops through active participation, interaction, and involvement in learning settings (Wiyono et al., 2025). From this perspective, learners can build knowledge more effectively when they actively engage with learning tools and instructional environments, thereby improving their learning results (Richter et al., 2025). Students' engagement with AI-supported learning systems has been shown to improve participation, learning efficiency, and academic achievement (Maamor et al., 2024). Furthermore, studies in AI-enhanced learning settings indicate that regular interaction with AI-based systems strengthens learners' knowledge acquisition and skill development. AI technologies offer individualized learning routes, adaptive guidance, and interactive study settings, thereby supporting students' learning

performance (Hu, 2024). Additional evidence shows that learners who actively engage with AI-supported learning systems achieve stronger learning participation and academic achievement (Dong et al., 2025). Therefore, this study proposes the following hypothesis:

H9: Use of AI-assisted music teaching positively influences students' learning outcomes.

TAM views perceived utility as a major factor shaping users' behavior and performance-related outcomes (Venkatesh & Davis, 2000). Evidence also shows that favorable judgments of educational technologies are related to stronger engagement and academic achievement. In AI-based learning contexts, students who regard such systems as useful show better learning performance and academic attainment (Dou & Feng, 2025). Students who perceive AI-based learning systems as useful demonstrate improved learning performance and academic achievement (Dong et al., 2025). Perceived utility positively affects learning effectiveness and academic results (Nuryakin et al., 2023). Accordingly, the following hypothesis is proposed:

H10: Perceived usefulness positively influences students' learning outcomes.

**Table 2. 1** Hypothesis development statement

| |
|---|
| **H1.** Facilitating conditions positively influence perceived ease of use. |
| **H2.** Facilitating conditions positively influence perceived usefulness. |
| **H3.** Perceived ease of use positively influences perceived usefulness. |
| **H4.** Perceived ease of use positively influences attitude toward AI-assisted music teaching. |
| **H5.** Perceived usefulness positively influences attitude toward AI-assisted music teaching. |
| **H6.** Perceived usefulness positively influences intention to use AI-assisted music teaching. |
| **H7.** Attitude toward AI-assisted music teaching positively influences intention to use AI-assisted music teaching. |
| **H8.** Intention to use AI-assisted music teaching positively influences use of AI-assisted music teaching. |
| **H9.** Use of AI-assisted music teaching positively influences students' learning outcomes. |
| **H10.** Perceived usefulness positively influences students' learning outcomes. |

## 2.5 Conclusion

The chapter then reviewed the main constructs in the proposed framework, including facilitating support, perceived usability, perceived utility, attitude toward AI-supported music instruction, intention to use it, actual use, and student learning results. Based on the preceding theoretical and empirical review, a conceptual model was established and related hypotheses were proposed. Therefore, this chapter provides the conceptual justification for the model and lays the groundwork for the methodology presented in the next chapter.



# CHAPTER 3
# METHODOLOGY

This chapter describes the methodological approach used to investigate how AI-assisted music teaching relates to students' learning outcomes. It first introduces the research paradigm and study design, and then explains the target population, sampling method, and sample size calculation. The chapter further presents the questionnaire structure and data collection process used in the study. Finally, the analytical procedures are explained, including descriptive statistics, measurement model assessment, and structural model assessment through Partial Least Squares Structural Equation Modeling (PLS-SEM).

## 3.1 Research Paradigm

The present investigation is guided by a positivist paradigm to assess how AI-assisted music teaching relates to students' learning outcomes. This paradigm is frequently used in quantitative studies because it stresses objective measurement, hypothesis verification, and statistical procedures for analyzing associations between variables (Park et al., 2019). In educational technology studies, it is often used to examine technology acceptance processes and educational results, as it enables researchers to evaluate proposed theoretical links through empirical data. Therefore, the positivist paradigm is suitable for the present study.

The present study seeks to analyze the associations among facilitating support, perceived usability, perceived utility, attitude toward AI-supported music instruction, intention to use such instruction, actual use, and student learning results. These associations are grounded in TAM and Constructivist Learning Theory and therefore require quantitative empirical examination. The positivist paradigm justifies the application of structured questionnaires, statistical procedures, and hypothesis verification to assess these associations objectively (Park et al., 2019).

Furthermore, the present research applies a quantitative survey approach to obtain student responses. This approach is appropriate for analyzing variable associations and verifying hypotheses (Ghanad, 2023). The collected survey responses will be analyzed through statistical procedures to test the connections among the constructs and evaluate the explanatory power of the proposed framework. Therefore, the positivist paradigm, deductive reasoning, and quantitative design are appropriate for achieving the objectives of this research.

## 3.2 Research Tools

### 3.2.1 Operational Definition of Variables

Table 3.1 presents the operational definitions of the variables used in the proposed model. Seven main constructs are included: facilitating support, perceived usability, perceived utility, attitude toward AI-supported music instruction, intention to use such instruction, actual use, and student learning results.

**Table 3. 1** Operational definitions of related variables

| Construct | Operational Definition | Source |
|---|---|---|
| Facilitating Conditions | Students' perceptions of the availability of resources, knowledge, compatibility, and technical support necessary for using AI-assisted music teaching. | Fokides and Daskalou (2026) |
| Perceived Ease of Use | Students' perceptions of the degree to which AI-assisted music teaching is easy to access, learn, and use with minimal effort. | Dou and Feng (2025) |
| Perceived Usefulness | Students' perceptions of the extent to which AI-assisted music teaching enhances learning convenience, efficiency, quality, and overall learning advantages. | Dou and Feng (2025) |
| Attitude toward AI-assisted music teaching | Students' overall positive or negative evaluation of using AI-assisted music teaching in music learning. | Dou and Feng (2025) |
| Intention to use AI-assisted music teaching | Students' willingness and readiness to adopt AI-assisted music teaching in their learning activities. | Dou and Feng (2025) |

**Table 3. 1** (Continued)

| Construct | Operational Definition | Source |
|---|---|---|
| Use AI-assisted music teaching | The extent to which students actually use AI-assisted music teaching in their music learning activities. | Yang et al. (2025) |
| Students' Learning Outcomes | Students' perceived improvement in learning effectiveness, learning performance, and learning experience quality resulting from the use of AI-assisted music teaching. | Eom et al. (2006) |

### 3.2.2 Variable Measurement Methods

All questionnaire items were assessed with a 5-point Likert format. A score of 1 represented strong disagreement, 2 represented disagreement, 3 represented neutrality, 4 represented agreement, and 5 represented strong agreement. Accordingly, the average scores were used to explain the extent to which students agreed with each statement.

#### 3.2.2.1 Facilitating Conditions

Table 3.2 shows the items for measuring facilitating conditions in AI-assisted music teaching. These items were adapted from Fokides and Daskalou (2026) and are related to TAM and its extended version. The initial items were revised to fit the AI-assisted music teaching setting while retaining their conceptual meaning. In the present study, facilitating conditions are assessed through four aspects: resource access, technical knowledge, system compatibility, and technical support. Each item was rated on a five-point Likert scale from 1 = strongly disagree to 5 = strongly agree. Higher scores represent stronger perceptions of support conditions for using AI-assisted music teaching.

**Table 3. 2** Items statements used to measure facilitating conditions

| Original items | Revised items | Source |
|---|---|---|
| I believe that I will have access to the resources needed to effectively use imVR in my teaching. | **FC1.** I believe that I have access to the resources necessary to effectively use AI-assisted music teaching. | Fokides and Daskalou (2026) |
| I have the necessary knowledge to use imVR in my educational activities. | **FC2.** I have the necessary knowledge to use AI-assisted music teaching in my learning activities. | |

**Table 3. 2** (Continued)

| Original items | Revised items | Source |
|---|---|---|
| imVR is compatible with other tools that I intend to use while teaching. | **FC3.** AI-assisted music teaching is compatible with other learning tools that I use in music learning. | Fokides and Daskalou (2026) |
| I am positive in receiving help from other colleagues if I encounter problems related to the use of imVR in my teaching. | **FC4.** I can receive help when I encounter difficulties while using AI-assisted music teaching. | |

#### 3.2.2.2 Perceived Ease of Use

Table 3.3 shows the items for measuring perceived usability in AI-assisted music teaching. These items were adapted from Dou and Feng (2025). In the present study, perceived usability is assessed through four aspects: access convenience, learning simplicity, task support, and effort reduction. These aspects capture students' views of how easily AI-assisted music teaching can be applied in music learning activities. Each item was rated on a five-point Likert scale from 1 = strongly disagree to 5 = strongly agree. Higher scores represent stronger perceived usability of AI-assisted music teaching.

**Table 3. 3** Measurement Items for Perceived Ease of Use in AI-Assisted Music Teaching

| Original Items | Revised Items | Source |
|---|---|---|
| I can access information technology useful for teaching with ease. | **PEOU1.** I can access AI-assisted music teaching tools with ease. | Dou and Feng (2025) |
| I can rapidly learn information technology useful for teaching. | **PEOU2.** I can quickly learn how to use AI-assisted music teaching. | |
| Using information technology can make it easier to complete my teaching tasks. | **PEOU3.** Using AI-assisted music teaching makes it easier to complete music learning tasks. | |
| Using information technology in teaching does not require much effort from me. | **PEOU4.** Using AI-assisted music teaching does not require much effort. | |

#### 3.2.2.3 Perceived Usefulness

Table 3.4 shows the items for measuring perceived utility in AI-assisted music teaching. These items were adapted from Dou and Feng (2025). The source items were adjusted to match the AI-assisted music teaching setting while retaining their conceptual meaning. In the present study, perceived utility is assessed through four aspects: learning convenience, learning quality, learning efficiency, and learning benefits. These aspects capture students' views of how far AI-assisted music teaching can improve their music learning performance.

**Table 3. 4** Measurement Items for Perceived Usefulness in AI-Assisted Music Teaching

| Original Items | Revised Items | Source |
|---|---|---|
| Information technology enables greater convenience in my teaching. | **PU1.** AI-assisted music teaching makes music learning more convenient. | Dou and Feng (2025) |
| Information technology enhances the quality of my teaching. | **PU2.** AI-assisted music teaching enhances the quality of music learning. | |
| Information technology improves the efficiency of my teaching. | **PU3.** AI-assisted music teaching improves learning efficiency. | |
| Information technology provides distinct advantages in my teaching practice. | **PU4.** AI-assisted music teaching provides distinct advantages in music learning. | |

#### 3.2.2.4 Attitude toward AI-assisted music teaching

Table 3.5 shows the items for measuring students' attitudes toward AI-assisted music teaching. These items were adapted from Dou and Feng (2025). The source items were adjusted to match the AI-assisted music teaching setting while preserving the conceptual meaning of the original scale. In the present study, attitude toward AI-assisted music teaching is assessed through four aspects: perceived consistency with educational development, alignment with educational reform trends, personal preference, and future expectations of technology use. These aspects capture students' general appraisal and views of AI-assisted music teaching in music learning.

**Table 3. 5** Items statements used to measure attitude toward AI-assisted music teaching

| Original Items | Revised Items | Source |
|---|---|---|
| I believe using information technology fits the development path of teaching practice. | AIT1. I believe AI-assisted music teaching fits the development of music education. | Dou and Feng (2025) |
| I think using information technology aligns with teaching reform trends. | AIT2. I think AI-assisted music teaching aligns with music education reform trends. | |
| I really like the role information technology plays in teaching. | AIT3. I like the role AI-assisted music teaching plays in music learning. | |
| I think information technology will be increasingly used in teaching. | AIT4. I think AI-assisted music teaching will be increasingly used in music education. | |

#### 3.2.2.5 Intention to use AI-assisted music teaching

Table 3.6 shows the items for measuring students' intention to use AI-assisted music teaching. These items were adapted from Dou and Feng (2025). In the present study, this construct is assessed through four aspects: usage intention, willingness to use, expectation of future use, and intention to follow technological innovations. These aspects capture students' readiness to adopt AI-assisted music teaching in music learning activities.

**Table 3. 6** Items Statements Used to Measure Intention to Use AI-Assisted Music Teaching

| Original Items | Original Items | Original Items |
|---|---|---|
| I will use information technology in my teaching. | I will use information technology in my teaching. | I will use information technology in my teaching. |
| I am very willing to use information technology in my teaching. | BI2. I am willing to use AI-assisted music teaching. | Dou and Feng (2025) |
| I hope to see more information technology tools used in teaching. | BI3. I hope to see more AI-assisted music teaching tools used in music learning. | Dou and Feng (2025) |
| I will keep up with innovations in the information technology used for teaching. | BI4. I will keep up with innovations in AI-assisted music teaching. | Dou and Feng (2025) |

#### 3.2.2.6 Use AI-assisted music teaching

Table 3.7 lists the statements for measuring students' actual application of AI-assisted music teaching. These statements were adapted from Yang et al. (2025). The source scale was adjusted to match the AI-assisted music teaching setting while preserving its original conceptual meaning. In the present study, actual application is assessed through four aspects: frequency of use, task-related use, reliance on technology, and regular use in learning activities. These aspects capture students' practical engagement with AI-assisted music teaching during music learning. Each statement was rated on a five-point Likert scale from 1 = strongly disagree to 5 = strongly agree. Higher scores represent a higher level of AI-assisted music teaching use.

**Table 3. 7** Items statements used to measure use AI-assisted music teaching

| Original Items | Revised Items | Source |
|---|---|---|
| I frequently use generative AI tools in my learning activities. | AU1. I frequently use AI-assisted music teaching in my learning activities. | Yang et al. (2025) |
| I use generative AI tools when completing learning tasks. | AU2. I use AI-assisted music teaching when completing music learning tasks. | Yang et al. (2025) |
| I rely on generative AI tools for learning support. | AU3. I rely on AI-assisted music teaching for music learning support. | Yang et al. (2025) |
| I use generative AI tools regularly in my study. | AU4. I regularly use AI-assisted music teaching in music learning. | Yang et al. (2025) |

#### 3.2.2.7 Students' Learning Outcomes

Table 3.8 shows the items for measuring student learning results in AI-assisted music teaching. These items were adapted from Eom et al. (2006), which focuses on students' perceived learning effectiveness in technology-supported learning environments. In this study, students' learning outcomes are measured across three aspects, including learning effectiveness, learning improvement, and learning experience quality. These aspects capture how students evaluate the contribution of AI-assisted music teaching to their music learning and performance improvement. All statements were scored with a five-point Likert format, ranging from 1 = strong disagreement to 5 = strong agreement. Higher scores indicate more favorable evaluations of students' learning results.

**Table 3. 8** Items statements used to measure students' learning outcomes

| Original Items | Original Items | Original Items |
|---|---|---|
| I feel that I learned as much from this course as I might have from a face-to-face version of the course. | LO1. I feel that I learn as much from AI-assisted music teaching as from traditional music learning. | Eom et al. (2006) |
| I feel that I learn more in online courses than in face-to-face courses. | LO2. I feel that I learn more through AI-assisted music teaching. | Eom et al. (2006) |
| The quality of the learning experience in online courses is better than in face-to-face courses. | LO3. AI-assisted music teaching improves the quality of my music learning experience. | Eom et al. (2006) |

## 3.3 Data Collection Management

### 3.3.1 Target Population

Respondents targeted in this research are music-major students enrolled in universities located in different regions of China. They are selected because they have previously encountered, used, or participated in learning activities involving AI-assisted music teaching tools. University music students were selected because artificial intelligence technologies are increasingly being integrated into higher education, particularly in practice-oriented disciplines such as music education, where students require continuous practice, personalized instruction, and immediate feedback. AI is increasingly used across universities for individualized study support, intelligent tutoring, plus automated feedback; these functions are especially useful in practice-intensive skill domains such as music education (UNESCO, 2023). In addition, a report from OECD (2023) highlighted that universities worldwide are increasingly implementing AI-based learning platforms, adaptive learning systems, and intelligent assessment tools to improve students' learning performance and learning experience. Furthermore, recent survey data indicate that artificial intelligence use among university students is rapidly increasing. According to a 2024 report from EDUCAUSE, more than 70% of university students reported using AI tools for learning activities, and over 60% indicated that AI technologies improved their learning efficiency and academic performance. Similarly, a 2024 global student survey conducted by QS reported that approximately 65% of university students used AI-based learning tools, and students in creative and performance-based disciplines showed higher

adoption rates due to the need for personalized feedback and skill development. In addition, research in music education contexts has shown that AI-assisted music learning systems support performance training, music composition, and ear training, making university music students an appropriate population for examining AI-assisted learning outcomes (Ou et al., 2025). Therefore, music-major students from various regions of China constitute a suitable study population for investigating how AI-assisted music teaching relates to students' learning results.

**3.3.2 Sampling techniques**

This research uses purposive sampling to recruit participants whose background and learning experience are directly connected with the the study. Purposive sampling is appropriate in educational research and technology adoption studies when the researcher needs respondents with particular knowledge, exposure, or experience related to the phenomenon being investigated (Campbell et al., 2020). Accordingly, the respondents in this research are music-major university students who have previously used, encountered, or learned through AI-assisted music teaching.

In addition, purposive sampling is frequently used in technology acceptance studies because researchers must ensure that participants have experience using or interacting with the technology being studied (Campbell et al., 2020). Because the study focuses on AI-assisted music teaching, respondents with prior experience using AI-based educational tools were selected to strengthen the validity and relevance of the data. Furthermore, recent studies on artificial intelligence adoption in education have also applied purposive sampling to select students who have experience with AI-based learning systems, as this approach improves data quality and research reliability (Schmidt et al., 2025).

Moreover, this study also applies convenience sampling within the purposive sampling framework by selecting participants from accessible universities offering music-related programs. Convenience sampling is commonly combined with purposive sampling in educational research because it allows researchers to efficiently collect data from available respondents while ensuring that participants meet specific research criteria (Campbell et al., 2020). This combined sampling strategy is appropriate for higher education studies in which participants need to meet specific academic or experiential conditions.

Therefore, the use of purposive sampling together with convenience sampling fits the purpose of this research, as it allows the researcher to reach music-major university students who have relevant experience with AI-assisted music teaching while also making the survey process more practical and manageable. This approach enables the study to obtain data from respondents who match the research focus, thereby supporting the examination of the relationship between AI-assisted music teaching and students' learning results.

**3.3.3 Sample Size**

The sample size needed for the present study was determined based on the item-to-response ratio commonly applied in questionnaire surveys and SEM analysis. Under this rule, each observed item should be matched with at least 15 participants so that the sample is sufficient for stable statistical estimation and model testing (Memon et al., 2020). This approach is widely applied in SEM studies because a sufficient number of responses helps generate stable parameter estimates and improve the robustness of the results. The questionnaire included 27 observed indicators across seven constructs: facilitating support, perceived usability, perceived utility, attitude toward AI-assisted music teaching, intention to use it, and actual use each contained four indicators, while student learning results contained three indicators. Following the 15:1 respondent-to-item guideline, the minimum sample was estimated at $27 \times 15 = 405$ respondents. Therefore, at least 405 respondents are required for this study. The number of valid samples collected from the questionnaire was 511. Furthermore, researchers suggest that larger sample sizes improve the accuracy and reliability of structural equation modeling results (Wolf et al., 2013). Therefore, the study plans to obtain a sample larger than the minimum requirement in order to strengthen the reliability and broader applicability of the results.

**3.3.4 Data collection technique**

The present research used a web-based survey as the main method for obtaining data, together with purposive and random sampling to improve the relevance and representativeness of the sample. The use of online questionnaires is widely recommended in educational technology research because it allows efficient data collection from geographically dispersed respondents while reducing time and cost (Wu et al., 2022).

After identifying eligible respondents through purposive sampling, random sampling was applied within the qualified group to enhance representativeness. Specifically, the questionnaire was distributed to music student groups across multiple universities, and participants were randomly invited to complete the survey.

Regarding the geographical scope, this study targeted university music students across China rather than limiting the sample to a specific province or institution. Previous studies suggest that expanding the geographical range improves sample diversity and enhances the generalizability of research findings (Shea et al., 2022). Therefore, the sample was drawn from universities across eastern, central, and western China to improve representativeness.

The questionnaire was distributed online for approximately four to six weeks. During this period, reminders were sent periodically to increase the response rate.

## 3.4 Data Analysis

### 3.4.1 Pre-text

A pre-test was carried out to assess the questionnaire' s clarity, internal consistency, and initial validity. Its main purpose was to confirm that the items were easy to understand, logically arranged, and appropriate for assessing the proposed variables within AI-assisted music teaching. Since the questionnaire was adapted from established measurement scales, the pre-test mainly focused on checking whether the adapted items were appropriate for university music students and whether the wording was consistent with the research context.

The pre-test involved music-major university students who had previously used or encountered AI-assisted music teaching tools. This group was chosen because it matched the target population of the formal survey. In total, 55 questionnaires were sent through a web-based survey platform, and 50 valid cases were kept after removing incomplete and invalid submissions.

The sample size of 50 valid responses was considered appropriate for the pre-test based on recommendations in the methodological literature. Hertzog (2008) suggested that pilot studies commonly employ sample sizes ranging from 10 to 50 participants to identify potential problems in questionnaire design and data collection procedures before the main survey. Similarly, Johanson and Brooks (2010) stated that 30 participants are usually

sufficient for pilot studies, while around 50 participants can generate more stable estimates of reliability and item performance. Therefore, obtaining 50 valid cases in the present study was above the basic requirement for pilot testing and adequate for assessing the questionnaire' s clarity, reliability, and initial validity before formal data collection.

The pre-test reliability results showed that Cronbach' s alpha values for all constructs were higher than 0.70, suggesting acceptable internal consistency. According to Nunnally and Bernstein (1994), an alpha coefficient of 0.70 or above is acceptable in exploratory studies, while coefficients exceeding 0.80 indicate strong reliability. Therefore, the reliability coefficients obtained in the present study confirmed satisfactory internal consistency among the questionnaire items.

**Table 3. 9** Reliability Results of the Pre-test

| Construct | Number of Items | Cronbach's Alpha |
|---|---|---|
| Facilitating Conditions (FC) | 4 | 0.812 |
| Perceived Ease of Use (PEOU) | 4 | 0.835 |
| Perceived Usefulness (PU) | 4 | 0.861 |
| Attitude toward AI-assisted Music Teaching (AIT) | 4 | 0.847 |
| Intention to Use AI-assisted Music Teaching (BI) | 4 | 0.872 |
| Use of AI-assisted Music Teaching (AU) | 4 | 0.819 |
| Students' Learning Outcomes (LO) | 3 | 0.806 |

The pre-test analysis yielded a Kaiser-Meyer-Olkin coefficient of 0.711. According to Kaiser (1974), KMO coefficients of 0.60, 0.70, 0.80, and 0.90 can be interpreted as acceptable, good, very good, and excellent levels of sampling adequacy, respectively. Thus, the obtained KMO coefficient indicated that the inter-item correlations were adequate and that the dataset was appropriate for factor analysis. Bartlett' s test of sphericity reached statistical significance ($p < 0.001$). This result shows that the correlation matrix differed from an identity matrix and that meaningful associations existed among the variables (Hair et al., 2019). Therefore, the questionnaire items showed sufficient correlation for further factor analysis. Overall, the KMO and Bartlett results offered initial support for construct validity and confirmed that the questionnaire was suitable for the formal survey.

**Table 3. 10** Pre-investigation KMO and Bartlett's test

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .711 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1836.115 |
| | df | 351 |
| | Sig. | .000 |

### 3.4.2 Descriptive Statistical Analysis

Descriptive statistics commonly include frequency, percentage, mean, and standard deviation, which help researchers understand the general patterns and features of the data prior to conducting further statistical analysis (Cooksey, 2020). In quantitative research, descriptive analysis plays an important role in identifying respondent characteristics, examining data distribution, and ensuring that the collected data are appropriate for subsequent model evaluation and hypothesis testing (Slater & Hasson, 2025).

In this study, descriptive statistical analysis will be conducted in two parts. First, frequency and percentage will be used to describe respondents' demographic characteristics, including gender, age, year of study, type of university, and frequency of using AI-assisted music teaching. These variables make it possible to outline the respondent profile of music-major university students involved in the survey. Second, descriptive indicators, particularly the mean score and standard deviation, will be used to summarize the core variables examined in the research model.

### 3.4.3 Measurement Model

Before examining the proposed links among the study variables, the measurement model should be assessed to confirm the precision, reliability, and validity of the latent constructs. In PLS-SEM, measurement model assessment is an essential step for judging whether the observed indicators adequately represent their related theoretical concepts and whether the later structural analysis can be interpreted reliably (Hair et al., 2021). This step is especially important when a model contains several latent variables measured by multiple indicators, such as facilitating support, perceived usability, perceived utility, attitude toward AI-assisted music teaching, intention to use it, actual use, and student learning results.

In the present study, the quality of the proposed measurement model will be evaluated using three criteria: internal consistency, convergent validity, and discriminant validity. First, construct reliability will be tested through Cronbach’s alpha and composite

reliability (CR). These two statistics are used to determine whether items under the same construct show adequate consistency and stability. Based on Hair et al. (2021), coefficients higher than 0.70 will be treated as acceptable. Therefore, Cronbach' s alpha and CR will be computed for each construct to verify the reliability of the measurement scale.

Convergent validity will then be evaluated using indicator loadings and AVE values. This type of validity concerns whether items intended to measure the same construct are strongly associated with one another. According to Hair et al. (2021), standardized factor loadings are generally expected to be higher than 0.70, and AVE above 0.50 suggests that the construct explains an adequate amount of variance in its indicators. These criteria will be used to determine whether each construct achieves acceptable convergent validity.

Furthermore, discriminant validity will be tested to determine whether the theoretical constructs are empirically distinct rather than conceptually overlapping. In this study, two widely used PLS-SEM procedures will be applied: the Fornell-Larcker criterion and the heterotrait–monotrait ratio (HTMT). Based on Hamid et al. (2017), HTMT values lower than 0.90 indicate acceptable discriminant validity. Under the Fornell-Larcker criterion, the square root of AVE for each construct should be greater than its correlations with other constructs (Hair et al., 2021). These tests will help confirm that the variables in the proposed framework have adequate empirical separation.

Overall, measurement model assessment supports the soundness of the questionnaire scales and lays the groundwork for later structural analysis. After verifying the constructs' reliability and validity, the present research can test the hypotheses and analyze the links between AI-related music teaching factors and students' learning results with stronger methodological rigor.

**3.4.4 Structural Model**

After validating the measurement model, structural analysis will be performed to test the proposed links among the latent constructs and assess whether the theoretical framework receives empirical support. In PLS-SEM, this stage focuses on evaluating the model' s predictive power and determining how much variance in the endogenous constructs is explained by the exogenous constructs (Hair et al., 2021). This analysis also provides an empirical basis for assessing the specified paths and verifying whether they are statistically significant.

In the present study, the structural model will be evaluated using several criteria, including path coefficients, $R^2$, $f^2$, and $Q^2$. Path estimates will first be inspected to determine the strength and direction of the links among constructs. The statistical significance of each proposed path will be tested through bootstrapping with 5,000 resamples. Following Hair et al. (2021), paths with p-values below 0.05 will be treated as statistically significant. This procedure will be used to test the proposed links among the constructs.

The model' s explanatory power will be evaluated through $R^2$. This statistic shows how much variance in each endogenous construct is accounted for by its related predictors. According to Hair et al. (2021), $R^2$ benchmarks of 0.25, 0.50, and 0.75 indicate low, medium, and high explanatory levels, respectively. In the present study, $R^2$ will be calculated for the endogenous constructs.

In addition, $f^2$ analysis will be used to assess the practical contribution of each predictor to endogenous constructs. The $f^2$ statistic shows how much a particular exogenous construct increases the model' s explanatory power. Based on Cohen (1988), $f^2$ values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively. This assessment helps determine the relative importance of each variable in the proposed framework.

Predictive relevance ($Q^2$) will also be tested through the blindfolding procedure to assess the model' s predictive power. A $Q^2$ statistic above zero shows that the model has predictive relevance for the relevant constructs (Hair et al., 2021). Accordingly, this procedure offers further support for the model' s capacity to predict students' acceptance and learning results in AI-assisted music teaching settings.

Overall, structural model evaluation provides the statistical basis for hypothesis testing and theoretical model verification. By analyzing the strength, statistical significance, and predictive performance of the specified links, this stage determines whether the research framework sufficiently explains how AI-assisted music teaching relates to students' learning results.

### 3.5 Conclusion

This section outlined the research methods used to investigate how AI-assisted music teaching relates to students' learning outcomes. It clarified the philosophical assumptions, target population, sampling strategy, sample size calculation, questionnaire development, and procedures for collecting data. It also described the analytical techniques. These procedures were intended to strengthen the credibility, validity, and analytical rigor of the dataset. By presenting a systematic design and analysis plan, this chapter established a methodological basis for testing the hypotheses and interpreting the empirical results. The next chapter reports the analytical results and explains the links between AI-assisted music teaching factors and students' learning results.

# CHAPTER 4
# RESEARCH RESULTS

This chapter presents the empirical results derived from data analysis and discusses the relationship between AI-assisted music teaching and students' learning outcomes. Subsequently, the structural model is assessed to test the proposed hypotheses and identify the paths among facilitating support, perceived usability, perceived utility, attitude toward AI-assisted music teaching, intention to use it, actual use, and student learning results.

## 4.1 Descriptive Analysis

**Table 4. 1** Sample Information

| Information and options | Frequency | Percent (%) |
|---|---|---|
| **Gender** | | |
| Male | 214 | 41.9 |
| Female | 297 | 58.1 |
| **Age** | | |
| 18–20 | 156 | 30.5 |
| 21–23 | 238 | 46.6 |
| 24–26 | 92 | 18 |
| Above 26 | 25 | 4.9 |
| **Year of Study** | | |
| First-year undergraduate student | 85 | 16.6 |
| Second-year undergraduate student | 121 | 23.7 |
| Third-year undergraduate student | 136 | 26.6 |
| Fourth-year undergraduate student | 118 | 23.1 |
| Postgraduate | 51 | 10 |

**Table 4. 1** (Continued)

| Information and options | Frequency | Percent (%) |
|---|---|---|
| **Type of University** | | |
| Comprehensive University | 162 | 31.7 |
| Normal University | 178 | 34.8 |
| Music/Art University | 171 | 33.5 |
| **Frequency of Using AI-assisted Music Teaching** | | |
| Rarely | 72 | 14.1 |
| Sometimes | 158 | 30.9 |
| Often | 181 | 35.4 |
| Very often | 100 | 19.6 |
| **Total** | 511 | 100 |

Table 4.1 summarizes the respondents' demographic profile. In total, 511 usable questionnaires were obtained. For gender, females made up 58.1% of the sample, while males accounted for 41.9%, showing a slightly higher share of female participants. In terms of age, the largest group was 21-23 years old (46.6%) suggesting that most respondents were undergraduate students at an early stage of study. Regarding academic year, third-year students formed the largest group (26.6%), followed by second-year students (23.7%) and fourth-year students (23.1%), showing a relatively even spread across study levels. For university type, respondents came from comprehensive universities (31.7%), normal universities (34.8%), and music or art universities (33.5%), which helped improve sample diversity. In addition, many respondents reported using AI-assisted music teaching often (35.4%) or sometimes (30.9%), indicating that most participants had relevant experience.

**Table 4. 2** Descriptive Statistics Results

| Study Variables | Items | Mean | S.D. | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Facilitating Conditions | FC1 | 3.89 | 0.721 | -0.623 | 0.342 |
| | FC2 | 3.95 | 0.704 | -0.658 | 0.398 |
| | FC3 | 3.84 | 0.738 | -0.587 | 0.291 |
| | FC4 | 3.81 | 0.752 | -0.551 | 0.276 |
| Perceived Ease of Use | PEOU1 | 3.97 | 0.693 | -0.689 | 0.401 |
| | PEOU2 | 4.02 | 0.671 | -0.724 | 0.435 |
| | PEOU3 | 3.94 | 0.702 | -0.615 | 0.322 |
| | PEOU4 | 3.88 | 0.718 | -0.594 | 0.297 |
| Perceived Usefulness | PU1 | 4.08 | 0.662 | -0.742 | 0.462 |
| | PU2 | 4.05 | 0.674 | -0.728 | 0.448 |
| | PU3 | 4.01 | 0.695 | -0.689 | 0.405 |
| | PU4 | 3.99 | 0.707 | -0.664 | 0.376 |
| Attitude toward AI-assisted music teaching | AIT1 | 4.11 | 0.651 | -0.785 | 0.481 |
| | AIT2 | 4.09 | 0.668 | -0.762 | 0.459 |
| | AIT3 | 4.05 | 0.681 | -0.724 | 0.412 |
| | AIT4 | 4.07 | 0.673 | -0.751 | 0.438 |
| Intention to use AI-assisted music teaching | BI1 | 4.13 | 0.642 | -0.803 | 0.506 |
| | BI2 | 4.16 | 0.631 | -0.829 | 0.521 |
| | BI3 | 4.09 | 0.667 | -0.755 | 0.468 |
| | BI4 | 4.02 | 0.693 | -0.701 | 0.421 |
| Use AI-assisted music teaching | AU1 | 3.87 | 0.722 | -0.612 | 0.315 |
| | AU2 | 3.83 | 0.734 | -0.589 | 0.298 |
| | AU3 | 3.79 | 0.745 | -0.561 | 0.276 |
| | AU4 | 3.85 | 0.728 | -0.601 | 0.304 |
| Students' learning outcomes | LO1 | 3.96 | 0.701 | -0.645 | 0.352 |
| | LO2 | 4.02 | 0.683 | -0.684 | 0.389 |
| | LO3 | 3.98 | 0.695 | -0.662 | 0.371 |

Table 4.2 reports the descriptive results for the measurement items. The item means ranged between 3.79 and 4.16, showing that respondents generally expressed favorable views of AI-assisted music teaching and the related constructs. Among all variables, intention to use AI-assisted music teaching recorded relatively higher mean scores, indicating students' strong readiness to adopt these tools. The standard deviations ranged from 0.631 to 0.752, suggesting moderate variation in respondents' answers. These statistics were within the acceptable range for normality, suggesting that the dataset was approximately normally distributed and appropriate for further analysis.

### 4.2 Measurement model

**Table 4. 3** Measurement Model Results

| Constructs | Items | Outer Loadings | Cronbach's Alpha | Composite Reliability | AVE |
|---|---|---|---|---|---|
| Facilitating Conditions | FC1 | 0.782 | 0.781 | 0.858 | 0.602 |
| | FC2 | 0.801 | | | |
| | FC3 | 0.744 | | | |
| | FC4 | 0.772 | | | |
| Perceived Ease of Use | PEOU1 | 0.796 | 0.794 | 0.866 | 0.618 |
| | PEOU2 | 0.823 | | | |
| | PEOU3 | 0.748 | | | |
| | PEOU4 | 0.777 | | | |
| Perceived Usefulness | PU1 | 0.824 | 0.808 | 0.874 | 0.635 |
| | PU2 | 0.808 | | | |
| | PU3 | 0.764 | | | |
| | PU4 | 0.792 | | | |
| Attitude toward AI-assisted | AIT1 | 0.846 | 0.824 | 0.884 | 0.656 |
| | AIT2 | 0.821 | | | |
| | AIT3 | 0.772 | | | |
| | AIT4 | 0.788 | | | |
| Intention to use AI-assisted | BI1 | 0.832 | 0.817 | 0.88 | 0.646 |
| | BI2 | 0.838 | | | |
| | BI3 | 0.774 | | | |
| | BI4 | 0.756 | | | |

**Table 4. 3** (Continued)

| Constructs | Items | Outer Loadings | Cronbach's Alpha | Composite Reliability | AVE |
|---|---|---|---|---|---|
| Use AI-assisted music | AU1 | 0.781 | 0.769 | 0.852 | 0.590 |
| | AU2 | 0.768 | | | |
| | AU3 | 0.708 | | | |
| | AU4 | 0.806 | | | |
| Students' Learning Outcomes | LO1 | 0.821 | 0.745 | 0.839 | 0.635 |
| | LO2 | 0.812 | | | |
| | LO3 | 0.753 | | | |

Table 4.3 reports the measurement model assessment results, including outer loadings, internal consistency, and convergent validity. The results show that all indicators had outer loadings between 0.708 and 0.846, exceeding the recommended 0.70 benchmark and supporting adequate indicator reliability. For construct reliability, Cronbach's alpha ranged from 0.745 to 0.824, while composite reliability (CR) ranged from 0.839 to 0.884. These values indicate acceptable internal consistency across all constructs. In addition, the AVE values ranged from 0.566 to 0.682, exceeding the 0.50 criterion and supporting convergent validity. Overall, the measurement model showed adequate reliability and validity, establishing a suitable basis for the following structural model analysis.

**Table 4. 4** Fornell–Larcker Criterion

| Constructs | FC | PEOU | PU | AIT | BI | AU | LO |
|---|---|---|---|---|---|---|---|
| FC | **0.776** | | | | | | |
| PEOU | 0.548 | **0.786** | | | | | |
| PU | 0.521 | 0.617 | **0.797** | | | | |
| AIT | 0.486 | 0.592 | 0.664 | **0.810** | | | |
| BI | 0.453 | 0.544 | 0.628 | 0.702 | **0.804** | | |
| AU | 0.402 | 0.451 | 0.509 | 0.536 | 0.611 | **0.768** | |
| LO | 0.395 | 0.473 | 0.582 | 0.551 | 0.533 | 0.597 | **0.797** |

Facilitating Conditions (FC); Perceived Ease of Use (PEOU); Perceived Usefulness (PU); Attitude toward AI-assisted music teaching (AIT); Intention to use AI-assisted music teaching (BI); Use AI-assisted music teaching (AU); Students' Learning Outcomes (LO)

**Table 4. 5** HTMT Results

| Constructs | FC | PEOU | PU | AIT | BI | AU | LO |
|---|---|---|---|---|---|---|---|
| **FC** | — | | | | | | |
| **PEOU** | 0.684 | — | | | | | |
| **PU** | 0.651 | 0.758 | — | | | | |
| **AIT** | 0.606 | 0.723 | 0.812 | — | | | |
| **BI** | 0.571 | 0.671 | 0.784 | 0.859 | — | | |
| **AU** | 0.522 | 0.566 | 0.639 | 0.671 | 0.771 | — | |
| **LO** | 0.503 | 0.602 | 0.728 | 0.685 | 0.662 | 0.742 | — |

Facilitating Conditions (FC); Perceived Ease of Use (PEOU); Perceived Usefulness (PU); Attitude toward AI-assisted music teaching (AIT); Intention to use AI-assisted music teaching (BI); Use AI-assisted music teaching (AU); Students' Learning Outcomes (LO)

Tables 4.4 and 4.5 summarize discriminant validity assessment using two established methods. In the study, discriminant validity indicates that each latent construct should capture a concept that is statistically distinguishable from the remaining constructs in the model. According to Fornell and Larcker (1981), this requirement is met when the square root of a construct' s AVE is higher than its correlations with other constructs. In Table 4.4, the diagonal entries represent the AVE square roots of the corresponding constructs. The results show that these values ranged from 0.768 to 0.810 and were higher than the related off-diagonal correlations. For example, facilitating conditions had an AVE square root of 0.776, exceeding its correlations with the other constructs, which ranged from 0.395 to 0.548. Similarly, perceived usefulness recorded an AVE square root of 0.797, also higher than its correlations with other constructs, which ranged from 0.509 to 0.664.

HTMT was used to assess discriminant validity in the measurement model. In PLS-SEM, HTMT is regarded as a rigorous method for judging whether different constructs reflect separate theoretical concepts (Hamid et al., 2017). HTMT coefficients below 0.90 indicate acceptable discriminant validity, while values lower than 0.85 offer stronger support for construct differentiation. As shown in Table 4.5, the HTMT values ranged from 0.503 to 0.859, all within the acceptable threshold. This suggests that the latent constructs did not show excessive overlap. Moreover, the Fornell-Larcker and HTMT results jointly support discriminant validity. These results indicate that each construct represents a

distinct component of the theoretical framework and can be empirically separated from the others. Therefore, the measurement model shows adequate discriminant validity and is appropriate for later structural model assessment.

### 4.3 Structural model

According to Hair et al. (2022), VIF values below 5.000 indicate that multicollinearity is not a serious issue in PLS-SEM, while values below 3.000 reflect a stricter acceptable level. Furthermore, Kock (2015) further suggested that VIF values below 3.300 indicate that severe collinearity and potential common method bias are unlikely to influence the results. Therefore, VIF < 5.000 was used as the main criterion, and VIF < 3.300 was applied as an additional conservative benchmark. As shown in Table 4.6, the VIF values ranged from 1.000 to 2.184, all of which were below the recommended threshold of 5.000. Therefore, collinearity did not pose a problem in this study.

**Table 4. 6** Collinearity Statistics (VIF)

| Endogenous Construct | Predictor Construct | VIF |
|---|---|---|
| PEOU | FC | 1.000 |
| PU | FC | 1.429 |
| PU | PEOU | 1.429 |
| AIT | PEOU | 1.615 |
| AIT | PU | 1.615 |
| BI | PU | 1.932 |
| BI | AIT | 1.932 |
| AU | BI | 1.000 |
| LO | PU | 1.514 |
| LO | AU | 1.514 |

Facilitating Conditions (FC); Perceived Ease of Use (PEOU); Perceived Usefulness (PU); Attitude toward AI-assisted music teaching (AIT); Intention to use AI-assisted music teaching (BI); Use AI-assisted music teaching (AU); Students' Learning Outcomes (LO)

The structural analysis showed that all ten proposed paths were positive and statistically significant, thereby supporting all hypotheses. Specifically, facilitating conditions had positive effects on perceived usability ($\beta = 0.548$, $p < 0.001$) and perceived utility ($\beta = 0.234$, $p < 0.001$). Perceived usability also predicted perceived utility ($\beta = 0.489$, $p < 0.001$) and students' attitudes toward AI-assisted music teaching ($\beta = 0.287$, $p < 0.001$). Moreover, perceived utility was positively associated with attitude ($\beta = 0.487$, $p < 0.001$), intention to use AI-assisted music teaching ($\beta = 0.311$, $p < 0.001$), and student learning results ($\beta = 0.341$, $p < 0.001$). Attitude toward AI-assisted music teaching also significantly promoted students' intention to use it ($\beta = 0.496$, $p < 0.001$). Among all paths, intention to use showed the strongest effect on actual use behavior ($\beta = 0.611$, $p < 0.001$). Finally, actual use positively contributed to student learning results ($\beta = 0.389$, $p < 0.001$). These results indicate that all hypothesized paths in the model received statistical support.

**Table 4. 7** Path Coefficients and Hypothesis Testing Results

| Hypothesis | Path | Beta (β) | *t* | p | Result |
|---|---|---|---|---|---|
| H1 | FC → PEOU | 0.548 | 14.237 | *** | Supported |
| H2 | FC → PU | 0.234 | 4.876 | *** | Supported |
| H3 | PEOU → PU | 0.489 | 10.412 | *** | Supported |
| H4 | PEOU → AIT | 0.287 | 5.621 | *** | Supported |
| H5 | PU → AIT | 0.487 | 9.443 | *** | Supported |
| H6 | PU → BI | 0.311 | 5.734 | *** | Supported |
| H7 | AIT → BI | 0.496 | 9.215 | *** | Supported |
| H8 | BI → AU | 0.611 | 16.084 | *** | Supported |
| H9 | AU → LO | 0.389 | 7.881 | *** | Supported |
| H10 | PU → LO | 0.341 | 6.694 | *** | Supported |

Facilitating Conditions (FC); Perceived Ease of Use (PEOU); Perceived Usefulness (PU); Attitude toward AI-assisted music teaching (AIT); Intention to use AI-assisted music teaching (BI); Use AI-assisted music teaching (AU); Students' Learning Outcomes (LO)

***: $p < 0.001$

**Table 4. 8** Coefficient of Determination ($R^2$)

| Endogenous Construct | R2 | Interpretation |
|---|---|---|
| Perceived Ease of Use (PEOU) | 0.300 | Moderate |
| Perceived Usefulness (PU) | 0.442 | Moderate |
| Attitude toward AI-assisted music teaching (AIT) | 0.486 | Moderate |
| Intention to use AI-assisted music teaching (BI) | 0.538 | Moderate |
| Use AI-assisted music teaching (AU) | 0.373 | Moderate |
| Students' Learning Outcomes (LO) | 0.417 | Moderate |

As shown in Table 4.8, facilitating conditions explained 30.0% of the variance in perceived usability. Perceived utility was explained by facilitating conditions and perceived usability, with these predictors accounting for 44.2% of its variance. For students' attitudes toward AI-assisted music teaching, perceived usability and perceived utility explained 48.6% of the variance. In addition, perceived utility and attitude jointly explained 53.8% of the variance in students' intention to use AI-assisted music teaching. Intention to use then explained 37.3% of the variance in actual use behavior. Finally, perceived utility and actual use together explained 41.7% of the variance in student learning results. Overall, the $R^2$ values suggest that the proposed model has moderate explanatory power, indicating that the selected constructs can explain students' acceptance and learning results in AI-assisted music teaching settings.

**Table 4. 9** Effect Size ($f^2$)

| Path | $f^2$ | Interpretation |
|---|---|---|
| FC → PEOU | 0.429 | Large |
| FC → PU | 0.057 | Small |
| PEOU → PU | 0.246 | Medium |
| PEOU → AIT | 0.112 | Small |
| PU → AIT | 0.326 | Medium |
| PU → BI | 0.141 | Small |
| AIT → BI | 0.381 | Large |
| BI → AU | 0.596 | Large |
| AU → LO | 0.232 | Medium |

Facilitating Conditions (FC); Perceived Ease of Use (PEOU); Perceived Usefulness (PU); Attitude toward AI-assisted music teaching (AIT); Intention to use AI-assisted music teaching (BI); Use AI-assisted music teaching (AU); Students' Learning Outcomes (LO)

The results in Table 4.9 show that facilitating conditions (FC) had a substantial effect on perceived usability (PEOU), with an $f^2$ value of 0.429. In addition, perceived usability made a moderate contribution to perceived utility (PU) ($f^2 = 0.246$). Perceived utility also produced a moderate influence on students' attitudes toward AI-assisted music teaching ($f^2 = 0.326$). Moreover, attitude toward AI-assisted music teaching showed a relatively strong effect on intention to use AI-assisted music instruction, with an $f^2$ value of 0.381, suggesting a medium-to-large impact. Overall, the $f^2$ results indicate that the antecedent variables explained the endogenous constructs to different extents in the proposed model. Among these paths, facilitating conditions and attitude toward AI-assisted music teaching showed stronger predictive effects.

**Table 4. 10** Predictive Relevance ($Q^2$)

| Construct | Q2 |
|---|---|
| Perceived Ease of Use (PEOU) | 0.183 |
| Perceived Usefulness (PU) | 0.269 |
| Attitude toward AI-assisted music teaching (AIT) | 0.301 |
| Intention to use AI-assisted music teaching (BI) | 0.347 |
| Use AI-assisted music teaching (AU) | 0.221 |
| Students' Learning Outcomes (LO) | 0.257 |

The model' s predictive relevance was evaluated through the blindfolding procedure. Table 4.10 shows that all $Q^2$ statistics exceeded zero, suggesting adequate predictive relevance for the endogenous constructs.

Figure 4.1 presents the structural model outcomes and shows the paths among facilitating conditions, perceived usability, perceived utility, attitude, behavioral intention, actual use, and student learning results. The findings show that facilitating conditions had significant effects on perceived usability ($\beta = 0.548$) and perceived utility ($\beta = 0.234$). Perceived usability further affected perceived utility ($\beta = 0.489$) and attitude toward AI-

assisted music teaching (β = 0.287). Perceived utility was also positively associated with attitude (β = 0.487), behavioral intention (β = 0.311), and student learning results (β = 0.341). In addition, attitude promoted behavioral intention (β = 0.496), which then strengthened actual use of AI-assisted music teaching (β = 0.611). Finally, actual use contributed to student learning results (β = 0.389). These results suggest that FC and PEOU affect LO indirectly through PU, attitude, BI, and AU, supporting the sequential mechanism based on TAM and the constructivist learning perspective.

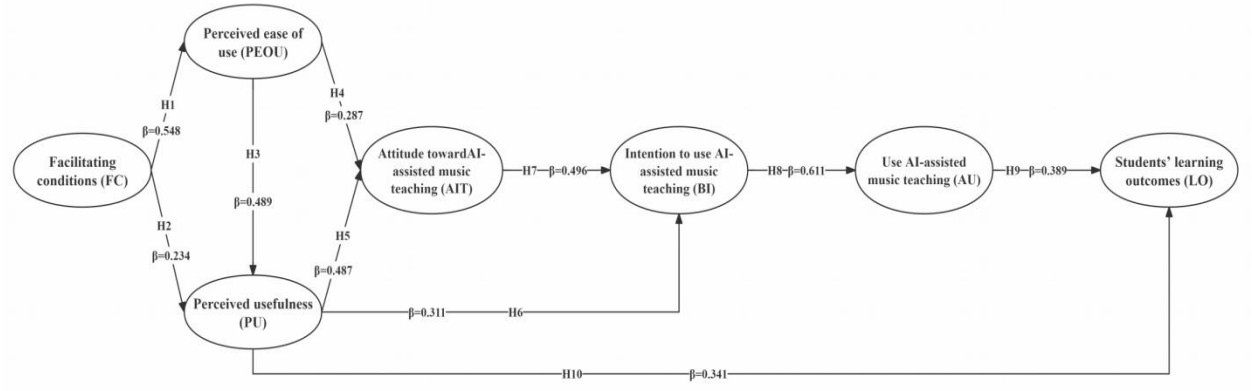



**Figure 4. 1** Model for students' learning outcomes

## 4.4 Conclusion

This chapter reported the empirical analysis of how AI-assisted music teaching relates to students' learning results. Overall, all hypotheses were supported, indicating that the conceptual framework received empirical support. These results offer empirical support for understanding students' acceptance of AI-assisted music teaching and its relationship with learning results. They also provide a basis for discussing the theoretical and practical implications in the next chapter.

# CHAPTER 5
# DISCUSSION AND CONCLUSION

This chapter discusses the conclusions, interpretations, practical suggestions, and limitations of the present study on AI-assisted music teaching and students' learning results. Based on the empirical results reported in Chapter Four, the chapter begins by summarizing the key conclusions according to the research objectives. It then interprets the results through the Technology Acceptance Model and Constructivist Learning Theory, followed by recommendations for educational practice and a discussion of study limitations.

## 5.1 Conclusion

*RO1. To examine the influence of facilitating conditions and perceived ease of use on perceived usefulness and students' attitudes toward AI-assisted music teaching.*

The findings revealed that facilitating conditions had a significant effect on perceived usability (H1, $\beta = 0.548$, $p < 0.001$) and perceived utility (H2, $\beta = 0.234$, $p < 0.001$). Perceived usability also predicted perceived utility (H3, $\beta = 0.489$, $p < 0.001$) and students' attitudes toward AI-assisted music teaching (H4, $\beta = 0.287$, $p < 0.001$). Moreover, perceived utility was significantly associated with students' attitudes toward AI-assisted music teaching (H5, $\beta = 0.487$, $p < 0.001$). These results suggest that sufficient technical support, learning resources, and guidance can help students view AI-assisted music teaching as more manageable and valuable. When students consider the system convenient to operate and useful for improving learning performance, they are more inclined to form favorable attitudes toward adopting these technologies.

*RO2. To investigate the influence of perceived usefulness and attitude on students' behavioral intention and actual use of AI-assisted music teaching.*

The findings revealed that perceived utility positively affected students' intention to use AI-assisted music teaching (H6, $\beta = 0.311$, $p < 0.001$), while attitude toward AI-assisted music teaching also significantly promoted use intention (H7, $\beta = 0.496$, $p < 0.001$). In addition, intention to use AI-assisted music teaching strongly predicted actual use (H8, $\beta = 0.611$, $p < 0.001$). These results suggest that students tend to develop stronger adoption intentions when they regard AI-assisted music teaching as academically valuable and hold favorable evaluations of it. In other words, students' intention can lead to actual engagement when they perceive the technology as useful and maintain positive attitudes toward its application.

*RO3. To examine the influence of perceived usefulness and actual use of AI-assisted music teaching on students' learning outcomes.*

The present findings showed that perceived utility had a significant effect on student learning results (H10, $\beta = 0.341$, $p < 0.001$), while practical use of AI-assisted music teaching also made a significant contribution to student learning results (H9, $\beta = 0.389$, $p < 0.001$). These results imply that learners who regard AI-assisted music teaching as valuable and actively engage with AI-based tools tend to achieve better learning results. Moreover, actual use showed a slightly stronger effect than perceived utility, suggesting that students' direct engagement with AI-assisted music teaching contributed more immediately to learning performance. Overall, facilitating support, perceived usability, perceived utility, attitude, use intention, and actual engagement were confirmed as significant factors explaining student learning results in the AI-assisted music teaching context.

## 5.2 Discussion

The RO1 findings are aligned with TAM, which explains that external support, such as facilitating conditions, can shape students' perceptions of system usability and utility. TAM also suggests that these cognitive beliefs are important antecedents of users' attitudes toward technology adoption. Recent empirical studies have reached similar conclusions, showing that supportive conditions can improve users' perceptions and acceptance of new educational technologies. Facilitating conditions and perceived usability affected learners' perceptions and attitudes toward digital learning technologies in educational settings. (Ebadi & Raygan, 2023a). Similarly, Chen et al. (2025) reported

that perceived usability strengthened perceived utility and shaped students' attitudes toward AI-based educational technologies. In addition, Linus et al. (2025) suggested that perceived utility directly contributes to students' attitudes toward technology adoption, meaning that students tend to form more favorable views when they regard educational technologies as useful.

Further evidence also supports the role of perceived usability and perceived utility in shaping students' attitudes toward AI-based learning settings. Duy et al. (2024) found that these two beliefs were important predictors of college students' attitudes toward AI-supported learning. Similarly, Muneer et al. (2026) reported that usability and utility perceptions influenced students' attitudes and their adoption of AI teaching assistants in higher education. Sustaningrum and Haldaka (2025) further confirmed that perceived utility directly affects learners' attitudes and technology adoption behavior in AI-supported learning settings. This finding differs slightly from some previous studies that reported stronger direct effects of facilitating conditions on perceived usefulness. One possible explanation is that students may first evaluate whether AI-assisted music teaching is easy to use before recognizing its usefulness.

The RO2 findings are aligned with the basic logic of TAM, which regards perceived utility and attitude as important antecedents of behavioral intention. Recent studies in higher education AI contexts have reported similar results. Linus et al. (2025) found that perceived utility and learners' attitudes significantly predicted their intention to use AI tools in university learning environments, with perceived utility identified as one of the strongest contributors. Similarly, Kim and Moon (2025) reported that perceived utility and attitude were central factors shaping students' intention to use ChatGPT and related AI tools in educational settings, further supporting the explanatory value of TAM in AI-supported learning research. Overall, these consistent findings indicate that students' willingness to adopt AI-based learning tools is shaped by both perceived academic value and favorable evaluations of the technology.

These findings are also in line with recent research on AI use in specific learning contexts. For example, studies on EFL students' Chat GPT acceptance showed that acceptance was linked to perceived utility, attitude, use intention, and practical engagement, and that learners with stronger intention tended to report higher levels of actual use (Liu & Ma, 2023).Similarly, research on Indonesian higher education students

emphasized that use intention helps explain AI-related learning performance and adoption results, while psychological and contextual conditions also support the movement from intention to technology-based learning behavior (Yan Yan & Jafri, 2026). Together, these studies support the present result that intention serves as a key link between students' favorable acceptance of AI and their real participation in learning practice.

At the same time, the study also differs from some recent evidence in meaningful ways. Positive attitudes were associated with stronger behavioral intentions toward AI, yet high intention did not always translate into actual use because barriers such as limited skills, academic integrity concerns, or contextual constraints could interrupt this transition (Polyportis, 2026). By contrast, this study found a strong and significant relationship between intention and actual use. One plausible explanation is that the present sample consisted of music-major university students who had already been exposed to AI-assisted music teaching, so the gap between intention and use may have been narrower than in more general AI adoption contexts. In other words, when students already possess relevant exposure and perceive the technology as directly applicable to their daily learning tasks, intention may more readily translate into actual engagement. This interpretation is also partly consistent with recent work on music student teachers in China, which suggests that willingness to use AI in music-related contexts can be shaped by domain-specific perceptions of usefulness and contextual readiness, although that study focused on future teaching application rather than current student learning use (Sultana et al., 2025).

Overall, the study suggests that perceived usefulness and attitude are both important antecedents of students' behavioral intention, and that behavioral intention in turn functions as a direct and meaningful predictor of actual use in AI-assisted music teaching. The results are broadly consistent with recent higher education AI studies in confirming the relevance of TAM, but they also extend the literature by showing that, in the specific context of music learning, the path from intention to actual use may be stronger than that reported in some more general AI learning settings. This indicates that domain relevance and prior exposure may reduce the common gap between intention and behavior, thereby making actual adoption of AI-assisted music teaching more likely once students perceive clear value and develop positive attitudes toward the technology.

The results associated with RO3 provide empirical support for the principles of constructivist learning theory, which suggests that meaningful learning occurs when learners actively participate in knowledge construction through interaction, exploration, and practical engagement. From this perspective, AI-assisted music teaching can facilitate students' learning development by providing opportunities for continuous practice, personalized support, and active involvement in learning activities. This interpretation is supported by previous research demonstrating that artificial intelligence-based learning applications can enhance students' academic achievement, learning efficiency, and engagement in higher education contexts (Villaver & Cabigas, 2025). Similarly, Maamor et al. (2024) found that AI-enhanced learning settings support personalized learning experiences, thereby improving learning performance and learner satisfaction.

The present findings further show that perceived utility and practical engagement with AI-assisted music teaching both contribute significantly to student learning results. This result aligns with recent studies highlighting the role of learners' perceived technological value in AI-supported educational settings. For example, Badr et al. (2024) reported that perceived utility had a significant effect on students' academic achievement and learning effectiveness Moreover, learners who frequently interacted with AI-based learning platforms showed stronger academic performance and greater engagement than those with limited technology usage. Therefore, the present study extends previous research by confirming that students' recognition of AI's learning benefits and their actual participation in AI-assisted music learning activities jointly contribute to improved educational outcomes.

However, this study also differs from some previous research. While several studies found that perceived usefulness had the strongest influence on learning outcomes, the present study found that actual use of AI-assisted music teaching had a slightly stronger effect than perceived usefulness. One possible explanation is that music education relies heavily on practical engagement, practice, and feedback. Therefore, students who actively use AI-assisted music teaching tools may experience more direct benefits in skill development and performance improvement. This finding extends prior research by emphasizing the value of active participation in AI-assisted music learning settings.

Overall, the study shows that perceived utility and practical use both contribute significantly to student learning results. This pattern aligns with recent evidence on the benefits of AI-supported instruction for academic outcomes, while also adding a music education perspective by highlighting actual engagement as a stronger driver. Thus, the findings offer empirical support for incorporating AI-assisted music teaching into higher education to improve students' learning performances.

## 5.3 Implication to Theories

### 5.3.1 Implication to technology acceptance model

The present study contributes to the theoretical extension of TAM in the setting of AI-assisted music teaching. The empirical results show that facilitating conditions affect students' perceived usability and perceived utility, and that perceived usability further shapes perceived utility and attitudes toward AI-assisted music teaching. In addition, perceived utility emerged as a key antecedent of students' attitudes. These results offer additional empirical support for the basic assumptions of TAM, which argue that users' cognitive judgments of technology, especially perceived utility and perceived usability, are central to technology acceptance.

Nevertheless, this research extends the traditional application of TAM in several important ways. First, previous TAM-based studies in educational contexts have largely concentrated on explaining technology acceptance, behavioral intention, and adoption decisions, with limited attention given to the relationship between technology acceptance and learning effectiveness. Similarly, (Chen et al., 2025)found that these two cognitive factors significantly shaped students’ attitudes toward AI-supported learning technologies. However, these studies mainly examined acceptance processes rather than educational consequences. By integrating TAM variables with students’ learning outcomes, this study expands the explanatory scope of TAM and demonstrates how technology acceptance mechanisms influence educational effectiveness in AI-assisted music learning contexts.

Second, the present study extends the scope of TAM by applying it to a discipline-specific educational setting. Prior studies have commonly used TAM to examine general educational technologies, such as online learning platforms, learning management systems, and digital learning settings. Existing evidence indicates that perceived usability and perceived utility influence students' acceptance of online learning systems (Nuryakin et al.,

2023), and TAM has also been supported in explaining the adoption of AI-based learning applications in wider educational contexts (Xue et al., 2026). However, relatively limited research has investigated technology acceptance mechanisms in subject-specific contexts, particularly in music education, where learning involves creativity, performance practice, skill development, and continuous interaction. By examining AI-assisted music teaching, this study demonstrates the applicability of TAM in a specialized learning domain and provides new insights into technology acceptance in creative disciplines.

Third, the present study further refines the internal logic of TAM by showing how perceived utility shapes students' attitudes toward AI-assisted music teaching. Prior studies have mainly emphasized the direct link between perceived utility and behavioral intention, regarding usefulness as a motivational factor in technology adoption (Chen et al., 2024). In contrast, the present results show that perceived utility also affects students' emotional and evaluative responses to AI-assisted music teaching. This suggests that students' recognition of the educational value of AI tools may first shape their attitudes before influencing later adoption behaviors, thereby enriching the theoretical interpretation of TAM in AI-supported learning settings.

Although facilitating conditions are often considered an external extension rather than a core component of traditional TAM frameworks, the findings demonstrate that environmental and institutional support significantly influence students' perceptions of AI-assisted learning technologies. This result is consistent with recent research emphasizing the role of external support mechanisms in artificial intelligence adoption (Hirzallah & Alshurideh, 2023). However, this study further reveals that facilitating conditions are particularly critical in AI-assisted music teaching, where technological infrastructure, accessible learning resources, and instructional support directly influence students' experiences with AI-based learning systems. Therefore, the present research strengthens the theoretical position of facilitating conditions within AI-enhanced educational environments.

Overall, the present research enriches TAM within AI-supported music education by offering four theoretical insights. First, it links technology acceptance mechanisms to student learning results, moving beyond a narrow focus on adoption behavior alone. Second, it broadens the applicability of TAM to a subject-specific setting characterized by music learning and creative skill development. Third, it clarifies the internal paths of TAM

by showing that perceived utility is a key antecedent of students' attitudes toward AI-assisted music teaching. Finally, it highlights facilitating support as an important contextual condition in AI technology acceptance. Together, these insights offer an integrated theoretical lens for explaining how learners evaluate, adopt, and gain learning benefits from AI-supported educational environments.

**5.3.2 Implication to constructivist learning theory**

Compared with previous studies, this research provides several new contributions to Constructivist Learning Theory. First, many previous studies applying Constructivist Learning Theory in educational technology have mainly focused on collaborative learning environments, online learning platforms, and student-centered teaching strategies. For example, recent research has shown that interactive learning environments and learner engagement significantly improve students' learning outcomes in digital learning contexts (Uzorka & Odebiyi, 2025). Similarly, another study found that students' active participation in technology-enhanced learning environments significantly improved knowledge construction and learning performance (Sailer et al., 2024). Therefore, this study contributes to Constructivist Learning Theory by applying it to AI-assisted music education contexts.

Second, previous research on Constructivist Learning Theory has mainly emphasized collaborative learning and peer interaction as key mechanisms for knowledge construction. However, AI-assisted music teaching introduces new forms of interaction between learners and intelligent systems. This study found that actual use significantly influenced students' learning outcomes, indicating that students construct knowledge through interaction with AI-assisted music tools. This finding differs slightly from traditional constructivist research that emphasizes human interaction as the primary source of knowledge construction. Instead, this study suggests that intelligent technologies can also facilitate knowledge construction and support learning processes. Recent studies have also suggested that artificial intelligence technologies provide personalized feedback, adaptive learning pathways, and interactive learning experiences that enhance students' knowledge construction (Fortuna et al., 2025).

Third, this study extends the application of Constructivist Learning Theory by demonstrating that students' perceptions of technological value can shape their learning outcomes in AI-assisted educational contexts. The findings reveal that perceived

usefulness significantly predicts students' learning outcomes, indicating that learners' cognitive evaluations of AI-assisted music teaching may influence how they engage with learning activities and construct knowledge. This perspective enriches constructivist views of learning by incorporating learners' perceptions of educational technologies as an important cognitive factor within the knowledge construction process. Supporting this argument, recent studies have shown that students' perceptions of technology-based learning environments significantly affect their engagement levels and academic performance in AI-supported learning settings (Khairuddin et al., 2024). Therefore, this study provides a broader interpretation of Constructivist Learning Theory by emphasizing the interaction between learners' technological perceptions and the process of knowledge development.

Furthermore, this study extends Constructivist Learning Theory to discipline-specific learning contexts such as music education. Music learning involves skill development, creativity, and experiential learning, which align with constructivist principles. However, limited studies have examined how AI-assisted tools influence music learning outcomes. This finding is consistent with recent studies suggesting that AI-supported learning environments enhance creativity and active learning in arts education (Zlateva, 2025). Therefore, this study contributes to Constructivist Learning Theory by extending its application to AI-assisted music learning environments.

Overall, this research advances Constructivist Learning Theory by providing empirical evidence on the role of AI-assisted music teaching in supporting students' learning development. Specifically, the findings demonstrate that students' active participation in AI-supported music learning activities contributes positively to their learning outcomes. Second, this study expands Constructivist Learning Theory by incorporating learner and AI system interaction into the knowledge construction process. Third, this study integrates learners' perceptions of usefulness into constructivist learning processes. Finally, this study extends Constructivist Learning Theory to discipline-specific contexts such as AI-assisted music education. These findings provide new theoretical insights into Constructivist Learning Theory and enhance its applicability in artificial intelligence-assisted learning environments.

### 5.4 Implication to practitioners

First, institutions should improve facilitating conditions to enhance students' perceptions of AI-assisted music teaching. Therefore, universities should provide adequate infrastructure such as stable internet access, AI-supported music learning platforms, and digital music laboratories. In addition, institutions should offer technical support services and training workshops to help students learn how to use AI-assisted music tools effectively. For example, universities may provide introductory sessions for AI-assisted music software, tutorials for AI-based composition tools, and support services for troubleshooting technical issues. These strategies can improve students' perceptions of facilitating conditions and increase their willingness to adopt AI-assisted music teaching.

Second, educators should improve system usability to enhance perceived ease of use. The findings indicated that perceived ease of use significantly influenced perceived usefulness and students' attitudes. Therefore, educators should select AI-assisted music platforms with user-friendly interfaces and intuitive features. Instructors should also provide clear instructions and step-by-step demonstrations during lessons. For example, teachers may demonstrate how to use AI tools for music composition, rhythm training, or pitch correction. Additionally, providing user guides, tutorial videos, and hands-on practice opportunities can reduce students' cognitive burden and enhance ease of use. These practical strategies can improve students' acceptance of AI-assisted music teaching.

Third, educators should incorporate AI-supported music technologies into authentic learning activities to maximize their educational value. For instance, AI-based applications can offer immediate feedback regarding students' pitch control, rhythmic accuracy, and vocal performance, while also providing support for creative activities such as music composition and improvisation. By embedding these tools into regular teaching practices, instructors can help students better understand the practical benefits of AI-assisted music learning and gradually develop more favorable perceptions and attitudes toward AI technologies.

Fourth, the findings demonstrate that students' intention to use AI-assisted music teaching serves as an important predictor of actual technology engagement, and that actual use contributes significantly to learning outcomes. Therefore, teachers should create more opportunities for students to apply AI-based music tools both during classroom instruction and in independent learning contexts. For example, instructors can design AI-supported

practice assignments, encourage students to employ AI applications in composition-related projects, and integrate AI activities into course requirements. These approaches may increase students' readiness to adopt AI technologies, encourage more frequent application, and ultimately improve the effectiveness of AI-supported music learning.

Finally, educators should use AI-assisted music teaching to support better learning results. The findings showed that perceived utility and practical use had significant effects on learning results. Therefore, instructors need to design activities that integrate AI music tools into learning tasks to improve students' performance. AI tools can support individualized learning routes, instant feedback, and adaptive practice activities. These strategies may strengthen students' learning performance and improve the overall quality of AI-assisted music teaching.

Overall, this study suggests that improving facilitating conditions, enhancing system usability, demonstrating usefulness, encouraging behavioral intention, and increasing actual use are critical strategies for implementing AI-assisted music teaching effectively.

### 5.5 Limitations and Future Research

Although the research offers useful insights into AI-assisted music teaching, several limitations need to be considered when interpreting the results. These limitations reveal possible constraints in the research design and also suggest directions for future studies.

First, the cross-sectional design limits the ability to identify causal links among the examined constructs. Although the PLS-SEM results revealed significant associations among the variables, the data were obtained from respondents at one specific time period, which limits the interpretation of temporal effects. In AI-assisted music learning environments, students’ perceptions, acceptance behaviors, and learning achievements may continue to develop as they accumulate experience with AI technologies. Future studies could employ longitudinal approaches to investigate the dynamic changes in students’ technology acceptance and learning development over extended periods. Since music learning is a progressive process involving repeated practice, continuous feedback, and gradual skill enhancement, longitudinal research may provide a more comprehensive understanding of how students’ attitudes, technology usage patterns, and learning outcomes develop over time.

Second, this research primarily depended on self-administered questionnaire responses, which may lead to potential concerns regarding common method bias. As all measurement indicators were derived from students' personal perceptions, the reported levels of AI usage and learning outcomes may not completely represent their actual behaviors or performance. Although self-report instruments are frequently applied in Technology Acceptance Model research, they may be influenced by respondents' subjective judgments. Future research could adopt mixed-method designs by integrating quantitative surveys with qualitative approaches, such as interviews, classroom observations, learning activity records, or case analyses. Combining multiple data sources would provide a deeper understanding of students' interactions with AI-assisted music technologies and offer more comprehensive evidence regarding how AI influences learning processes and outcomes.

Third, the sample of this study was limited to university students who participated in AI-assisted music teaching restrict the generalizability of the findings. Students from different educational levels, such as primary schools, secondary schools, or professional music institutions, may have different perceptions of AI-assisted music teaching. In addition, students from different cultural and institutional backgrounds may respond differently to AI-assisted learning environments. Future research should broaden the sample by involving learners from diverse educational stages, geographic areas, institutional types, and cultural contexts. Comparative research could also examine whether contextual differences shape students' acceptance of AI-assisted music teaching and their learning results.

Fourth, this study focused on the Technology Acceptance Model and Constructivist Learning Theory as the theoretical foundation. Although these theories provided a strong framework for examining AI-assisted music teaching, other factors that may influence students' learning outcomes were not included in the model. For example, students' digital literacy, learning motivation, prior music experience, teacher support, and AI literacy may also influence students' acceptance, actual use, and learning outcomes. Future research may incorporate additional variables to extend the research model. In addition, future studies may integrate other theoretical frameworks, such as Self-Determination Theory or Social Cognitive Theory, to develop a more comprehensive model of AI-assisted music learning.

Finally, this study focused on students' general perceptions of AI-assisted music teaching rather than examining specific AI tools or platforms. Different AI-assisted music systems may vary in functionality, usability, feedback quality, interaction design, and effectiveness, which may influence students' learning outcomes. Future research may examine the effectiveness of different AI-assisted music teaching tools, such as AI composition systems, AI feedback systems, AI ear-training platforms, and AI music practice applications. By comparing different types of AI-assisted music tools, future studies may identify which technologies are most effective for improving students' learning outcomes and provide more practical guidance for educators and institutions when selecting AI-assisted music teaching technologies.

Overall, although this study provides important insights into AI-assisted music teaching and students' learning outcomes, the above limitations suggest that future research should improve research design, expand sample diversity, enrich measurement methods, extend the theoretical framework, and examine different AI-assisted music teaching tools. These future directions may further enhance the understanding of how AI-assisted music teaching influences students' learning outcomes in diverse educational contexts.

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# APPENDIXES



# APPENDIX A

## Questionnaire

**Appendix A:** Questionnaire (English version)

Dear Respondent,

You are invited to participate in this research study titled "The Influence of Artificial Intelligence-Assisted Music Teaching on Students' Learning Outcomes." The purpose of this study is to examine how artificial intelligence-assisted music teaching affects students' learning outcomes. Your participation in this survey is voluntary, and your responses will be used solely for academic research purposes.

This questionnaire is divided into eight sections. The first section includes screening questions to ensure that participants meet the study requirements and demographic information. The remaining sections measure facilitating conditions, perceived ease of use, perceived usefulness, attitude toward AI-assisted music teaching, intention to use AI-assisted music teaching, use of AI-assisted music teaching, and students' learning outcomes.

This questionnaire will take approximately 10–15 minutes to complete. All responses will remain anonymous and confidential, and no personal identifying information will be collected. There are no right or wrong answers. Please answer each question based on your actual experience and opinions. Your participation is greatly appreciated and will contribute to research on artificial intelligence-assisted music teaching and music education development. Thank you for your valuable time and support.

**Part 1 Basic information**

**Q1. Are you currently a university student majoring in music?**

☐ Yes

☐ No (If No, please stop here. Thank you for your participation.)

**Q2. Have you used or been exposed to AI-assisted music teaching tools?**

☐ Yes

☐ No (If No, please stop here. Thank you for your participation.)

**Q3. Gender**

☐ Male

☐ Female

**Q4. Age**

☐ 18–20

☐ 21–23

☐ 24–26

☐ Above 26

**Q5. Year of Study**

☐ Freshman

☐ Sophomore

☐ Junior

☐ Senior

☐ Postgraduate

**Q6. Type of University**

☐ Comprehensive University

☐ Normal University

☐ Music/Art University

**Q7. Frequency of using AI-assisted music teaching**

☐ Rarely (less than once a month)

☐ Sometimes (several times a month)

☐ Often (several times a week)

☐ Very often (almost every day)

**Part 2 Facilitating Conditions**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| FC1. I believe that I have access to the resources necessary to effectively use AI-assisted music teaching. | | | | | |
| FC2. I have the necessary knowledge to use AI-assisted music teaching in my learning activities. | | | | | |
| FC3. AI-assisted music teaching is compatible with other learning tools that I use in music learning. | | | | | |
| FC4. I can receive help when I encounter difficulties while using AI-assisted music teaching. | | | | | |

**Part 3 Perceived Ease of Use**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PEOU1. I can access AI-assisted music teaching tools with ease. | | | | | |
| PEOU2. I can quickly learn how to use AI-assisted music teaching. | | | | | |
| PEOU3. Using AI-assisted music teaching makes it easier to complete music learning tasks. | | | | | |
| PEOU4. Using AI-assisted music teaching does not require much effort. | | | | | |

**Part 4 Perceived Usefulness**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PU1. AI-assisted music teaching makes music learning more convenient. | | | | | |
| PU2. AI-assisted music teaching enhances the quality of music learning. | | | | | |
| PU3. AI-assisted music teaching improves learning efficiency. | | | | | |
| PU4. AI-assisted music teaching provides distinct advantages in music learning. | | | | | |

**Part 5 Attitude toward AI-assisted music teaching**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| AIT1. I believe AI-assisted music teaching fits the development of music education. | | | | | |
| AIT2. I think AI-assisted music teaching aligns with music education reform trends. | | | | | |
| AIT3. I like the role AI-assisted music teaching plays in music learning. | | | | | |
| AIT4. I think AI-assisted music teaching will be increasingly used in music education. | | | | | |

**Part 6 Intention to use AI-assisted music teaching**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| BI1. I intend to use AI-assisted music teaching in my learning. | | | | | |
| BI2. I am willing to use AI-assisted music teaching. | | | | | |
| BI3. I hope to see more AI-assisted music teaching tools used in music learning. | | | | | |
| BI4. I will keep up with innovations in AI-assisted music teaching. | | | | | |

**Part 7 Use AI-assisted music teaching**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| AU1. I frequently use AI-assisted music teaching in my learning activities. | | | | | |
| AU2. I use AI-assisted music teaching when completing music learning tasks. | | | | | |
| AU3. I rely on AI-assisted music teaching for music learning support. | | | | | |
| AU4. I regularly use AI-assisted music teaching in music learning. | | | | | |

**Part 8 Students' Learning Outcomes**

Please indicate your level of agreement with the following statements (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| LO1. I feel that I learn as much from AI-assisted music teaching as from traditional music learning | | | | | |
| LO2. I feel that I learn more through AI-assisted music teaching | | | | | |
| LO3. AI-assisted music teaching improves the quality of my music learning experience | | | | | |

Thank you very much for taking the time to complete this questionnaire. Your participation is greatly appreciated and your responses are valuable to this research on the influence of AI-assisted music teaching on students' learning outcomes. All information provided will be kept strictly confidential and used only for academic purposes. Your contribution will help improve understanding of artificial intelligence-assisted music teaching and support the development of more effective music learning environments. Thank you again for your time and support !

**Appendix A:** Questionnaire (Chinese version)

尊敬的受访者：

诚邀您参与题为《人工智能辅助音乐教学对学生学习成果的影响》的研究调查。本研究旨在探究人工智能辅助音乐教学对学生学习成效的作用机制。您的参与出于完全自愿，所有反馈数据将严格用于学术研究用途。

本问卷共分为八个部分。第一部分包含筛选问题，用于确认参与者是否符合研究要求及收集人口统计学信息。其余部分分别评估以下维度：便利条件、感知易用性、感知有用性、对人工智能辅助音乐教学的态度、使用人工智能辅助音乐教学的意向、实际使用情况以及学生学习成果。

本问卷填写时间约为 10-15 分钟。所有回答均将匿名处理并严格保密，且不会收集任何个人身份识别信息。问卷无正确或错误选项，请根据您的实际经历及观点对每个问题进行回答。

**第1部分 基本信息**

**Q1. 您目前是音乐专业的大学生吗？**

☐ 是

☐ 否（若选择“否”，请在此处停止。感谢您的参与。）

**Q2. 您是否使用过或接触过人工智能辅助音乐教学工具？**

☐ 是

☐ 否（若选择“否”，请在此处停止。感谢您的参与。）

**Q3. 性别**

☐ 男

☐ 女

**Q4. 年龄**

☐ 18 - 20

☐ 21 - 23

☐ 24 - 26

☐ 26 岁以上

**Q5. 年级**

☐ 大一

☐ 大二

☐ 大三

☐ 大四

☐ 研究生

**Q6. 大学类型**

☐ 综合大学

☐ 师范大学

☐ 音乐与艺术大学

**Q7. 人工智能辅助音乐教学使用频率**

☐ 很少（每月少于一次）

☐ 有时（每月数次）

☐ 经常（每周数次）

☐ 非常常见（几乎每天）

**第 2 部分 便利条件**

请根据以下陈述表明您的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| 陈述 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| FC1. 我确信自己具备有效运用人工智能辅助音乐教学所需资源的能力。 | | | | | |
| FC2. 我具备在学习活动中运用人工智能辅助音乐教学所需的知识。 | | | | | |
| FC3. AI 辅助音乐教学与我在音乐学习中使用的其他学习工具兼容。 | | | | | |
| FC4. 在使用人工智能辅助音乐教学过程中遇到困难时，我可以获得帮助。 | | | | | |

**第 3 部分 感知易用性**

请表明您对以下陈述的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| 陈述 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PEOU1. 我能轻松使用人工智能辅助音乐教学工具。 | | | | | |
| PEOU2. 我能快速掌握人工智能辅助音乐教学的使用方法。 | | | | | |
| PEOU3. 采用人工智能辅助音乐教学可更便捷地完成音乐学习任务。 | | | | | |
| PEOU4. 采用人工智能辅助音乐教学无需耗费过多精力。 | | | | | |

**第 4 部分 感知有用性**

请根据以下陈述表明您的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| 陈述 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PU1. 人工智能辅助音乐教学使音乐学习更加便捷。 | | | | | |
| PU2. 人工智能辅助音乐教学提升音乐学习质量。 | | | | | |
| PU3. AI 辅助音乐教学提升学习效率。 | | | | | |
| PU4. 人工智能辅助音乐教学在音乐学习中具有显著优势。 | | | | | |

**第 5 部分 对人工智能辅助音乐教学的态度**

请根据以下陈述表明您的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| 陈述 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| AIT1. 我认为人工智能辅助音乐教学符合音乐教育的发展趋势。 | | | | | |
| AIT2. 我认为人工智能辅助音乐教学符合音乐教育改革趋势。 | | | | | |
| AIT3. 我认同人工智能辅助音乐教学在音乐学习中的作用。 | | | | | |
| AIT4. 我认为人工智能辅助音乐教学将在音乐教育中得到日益广泛应用。 | | | | | |

**第 6 部分 使用人工智能辅助音乐教学的意向**

请根据以下陈述表明您的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| BI1. 我计划在我的学习中采用人工智能辅助音乐教学。 | | | | | |
| BI2. 我愿意采用人工智能辅助音乐教学。 | | | | | |
| BI3. 我希望在音乐学习中看到更多人工智能辅助音乐教学工具的应用。 | | | | | |
| BI4. 我将持续关注人工智能辅助音乐教学领域的创新进展。 | | | | | |

**第 7 部分 人工智能辅助音乐教学应用**

请根据以下陈述表明您的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| 陈述 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| AU1. 我在学习活动中经常使用人工智能辅助音乐教学。 | | | | | |
| AU2. 我在完成音乐学习任务时采用人工智能辅助音乐教学法。 | | | | | |
| AU3. 我依赖人工智能辅助音乐教学来支持音乐学习。 | | | | | |
| AU4. 我在音乐学习中常采用人工智能辅助音乐教学法。 | | | | | |

**第 8 部分 学生学习成果**

请根据以下陈述表明您的同意程度（1=强烈不同意，2=不同意，3=中立，4=同意，5=强烈同意）。

| Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| LO1. 我认为从人工智能辅助音乐教学中获得的学习效果与传统音乐学习相当。 | | | | | |
| LO2. 我认为通过人工智能辅助音乐教学能获得更丰富的学习体验 | | | | | |
| LO3. AI 辅助音乐教学提升我的音乐学习体验质量 | | | | | |

衷心感谢您抽出宝贵时间完成本次问卷调查。您的参与对我们研究人工智能辅助音乐教学对学生学习成效的影响具有重要价值，您的反馈将为这项研究提供关键数据支持。所有信息均将严格保密，仅用于学术研究目的。您的参与将有助于深化对人工智能辅助音乐教学的理解，并为构建更高效的音乐学习环境提供支持。再次感谢您投入宝贵时间与支持！

# APPENDIX B

## Article

**Appendix B:** Article

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# Technology Acceptance, Actual Use, and Learning Outcomes in AI-Assisted Music Teaching: Evidence from Chinese University Students

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**Abstract:** The objectives of this research were (1) to examine the influence of facilitating conditions and perceived ease of use on perceived usefulness and students' attitudes toward AI-assisted music teaching, (2) to investigate the influence of perceived usefulness and attitude on students' behavioral intention and actual use of AI-assisted music teaching, and (3) to examine the influence of perceived usefulness and actual use of AI-assisted music teaching on students' learning outcomes. This study employed a quantitative research approach, collecting data through an online questionnaire using purposive sampling combined with convenience and random sampling from 511 valid university students majoring in music from multiple universities across different regions of China who had experience with or exposure to AI-assisted music teaching tools. The analysis included descriptive statistics, measurement model evaluation, and structural model evaluation using partial least squares structural equation modeling to test the proposed hypotheses.Major findings: (1) on the influence of facilitating conditions and perceived ease of use, the results showed that facilitating conditions significantly influenced perceived ease of use and perceived usefulness, while perceived ease of use significantly influenced perceived usefulness and students' attitudes toward AI-assisted

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music teaching; (2) on the influence of perceived usefulness and attitude, the results showed that perceived usefulness significantly influenced attitude and behavioral intention, while attitude significantly influenced behavioral intention and behavioral intention significantly influenced actual use of AI-assisted music teaching; and (3) on the influence of perceived usefulness and actual use on learning outcomes, the results showed that perceived usefulness and actual use both significantly influenced students' learning outcomes.

**Keywords:** Artificial intelligence-assisted music teaching, learning outcomes, Technology Acceptance Model, Constructivist Learning Theory, university students, music education

## 1.Introduction

Artificial intelligence (AI) has become an important driving force in educational transformation by supporting personalized learning, adaptive instruction, intelligent feedback, and data-driven learning environments (Wang et al., 2024). With the rapid development of machine learning, natural language processing, and intelligent recommendation systems, AI technologies are increasingly being integrated into various educational contexts. These technologies enable students to access learning materials more flexibly and receive immediate feedback that supports individualized learning(Lee et al., 2025). In music education, AI-assisted teaching can provide real-time performance evaluation, personalized learning content, adaptive practice activities, and intelligent instructional support, which may enhance students' engagement, motivation, and learning outcomes . Compared with traditional teacher-centered music instruction, AI-assisted music teaching offers more opportunities for continuous practice and individualized learning experiences(Mohd Amin et al., 2025). However, the effectiveness of AI-assisted music teaching depends not only on the availability of technology but also on students' acceptance and actual use of these technologies. Factors such as facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use significantly influence students' learning outcomes in technology-enhanced learning environments (Du, 2025).

Existing studies mainly focus on the technical applications and functional advantages of AI in music education, while limited attention has been given to the mechanisms through which AI influences students' learning outcomes (Liang & Reiss, 2025). In addition, previous research often examines technology acceptance and learning outcomes separately, and student-centered empirical evidence remains insufficient (Novak et al., 2023). Some studies emphasize creativity enhancement and intelligent learning systems, but few studies integrate technology acceptance variables with learning outcomes within a comprehensive theoretical framework. Therefore, this study integrates the Technology Acceptance Model and Constructivist Learning Theory to examine how facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use influence students' learning outcomes in AI-assisted music teaching(Chen et al., 2025).

This study has both theoretical and practical significance. Theoretically, it extends the Technology Acceptance

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Model by linking technology acceptance variables with learning outcomes and contributes to constructivist learning theory in technology-enhanced music education (Niu, 2026). Practically, the findings may help educators, educational institutions, and AI system developers improve AI-assisted music teaching and create more effective learning experiences(Nuryakin et al., 2023). A quantitative research design was adopted using a structured questionnaire distributed to university students with experience in AI-assisted music teaching(Cabellos et al., 2024). Data were analyzed using Structural Equation Modeling to test the proposed relationships among variables. This study was limited to university students and focused only on selected variables within the proposed framework.

## 2. Literature Review

### 2.1 Research context

Artificial intelligence (AI) has become an important driver of educational transformation, especially in higher education, through personalized learning, adaptive instruction, and intelligent feedback systems (Schmidt et al., 2025). International organizations such as UNESCO and OECD have emphasized that AI technologies can improve teaching effectiveness, learning flexibility, and student engagement in digital learning environments (Chigbu & Makapela, 2025). In higher education, AI applications such as intelligent tutoring systems, adaptive learning platforms, and automated assessment tools provide personalized learning support and continuous feedback, which contribute to improved learning outcomes(Maamor et al., 2024). However, the effectiveness of AI-assisted learning depends not only on technology availability but also on students' acceptance, perceptions, and actual usage behaviors (Létourneau et al., 2025).

In music education, AI technologies are increasingly applied in performance evaluation, ear training, music composition, and interactive learning environments (Ma, 2025). AI-assisted music learning systems can analyze students' performance data and provide adaptive learning content and real-time feedback, which help students improve musical skills more efficiently (Mustofa et al., 2025). Studies have shown that AI-supported music learning can enhance students' self-efficacy, learning engagement, and performance outcomes (Tan et al., 2025). In addition, AI-based composition and music generation tools encourage creativity and support constructivist learning by promoting active knowledge construction and exploration of musical ideas (Chen & Sun, 2024).

China has also actively promoted the integration of artificial intelligence into higher education through national strategies such as the "New Generation Artificial Intelligence Development Plan" and the "Smart Education of China" initiative (Ou et al., 2025). Chinese universities increasingly adopt AI technologies in teaching, learning analytics, and personalized learning environments to improve teaching quality and student performance (Zhu, 2026). However, challenges such as insufficient infrastructure, limited technical support, and students' perceptions of usefulness and ease of use continue to influence the effectiveness of AI-assisted learning (Ruano-Borbalan, 2025).

For university music students, AI-assisted learning provides flexible practice opportunities, personalized instruction, and continuous feedback beyond traditional classroom settings (Bognár & Khine, 2025). However, students' attitudes, behavioral intention, and actual use significantly influence whether AI-assisted music education

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can improve learning outcomes (Cheng, 2025). Therefore, this study applies the Technology Acceptance Model and Constructivist Learning Theory to examine how Chinese university music students accept and use AI-assisted music teaching and how these factors influence their learning outcomes.

**2.2 Parent Disciplines**

**2.2.1 Technology Acceptance Model (TAM)**

The Technology Acceptance Model (TAM), is widely used to explain individuals' acceptance of new technologies(Herington et al., 2026). TAM proposes that perceived usefulness and perceived ease of use influence users' attitudes, behavioral intentions, and actual use of technology(Fortuna et al., 2025). Specifically, perceived usefulness refers to the degree to which individuals believe that using a particular system will enhance their performance, while perceived ease of use refers to the degree to which they believe that using the system will be free of effort. These two core constructs jointly shape users' cognitive evaluations, which subsequently determine their affective responses and behavioral decisions toward technology adoption. Recent studies confirm that these factors significantly affect students' acceptance of AI-assisted learning systems (Huang, 2024), particularly in higher education contexts where digital learning tools are increasingly prevalent.

Extended TAM models further incorporate additional variables such as facilitating conditions, attitude, and actual use to better explain technology adoption in educational settings (Zhu, 2024). Facilitating conditions highlight the importance of external support, including institutional resources, technical infrastructure, and guidance, which can significantly influence users' perceived ease of use and perceived usefulness. These extensions provide a more comprehensive understanding of technology acceptance behavior, especially in complex learning environments where multiple contextual factors interact.

Therefore, this study applies TAM to examine students' acceptance of AI-assisted music teaching and its influence on learning outcomes. By integrating both core and extended TAM constructs, the study aims to provide a more holistic explanation of how students perceive, adopt, and utilize AI-based music learning systems. To address these limitations, this study applies TAM to examine students' acceptance of artificial intelligence-assisted music teaching and its influence on learning outcomes. As shown in Figure 2.1.

**2.2.2 Constructivist Learning Theory**

Constructivist learning theory explains that learners actively construct knowledge through interaction, experience, and reflection rather than passively receiving information(Davis et al., 1989). From this perspective, learning is viewed as an active and dynamic process in which students interpret new information based on prior knowledge, engage in meaningful learning tasks, and continuously refine their understanding through social and contextual engagement. The theory emphasizes key principles such as active learning, collaboration, contextual learning, and learner autonomy, all of which contribute to improved learning outcomes in technology-enhanced environments (Do et al., 2023). In particular, constructivism highlights that knowledge construction is most effective when learners are placed in authentic learning situations that encourage exploration, problem-solving,

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and reflective thinking.

Artificial intelligence-assisted learning environments strongly support these constructivist principles by providing personalized feedback, adaptive learning content, and interactive learning experiences (Shan et al., 2025). AI systems can simulate real-time instructional guidance, adjust learning difficulty based on learner performance, and offer continuous performance evaluation, thereby creating a more individualized and learner-centered educational environment. In addition, AI tools enable students to repeatedly practice and refine their skills at their own pace, which is especially important in skill-based disciplines such as music education. In music learning contexts, AI-assisted teaching promotes independent practice, immediate feedback on performance accuracy, and iterative improvement, all of which enhance students' ability to construct musical knowledge actively rather than relying solely on teacher instruction(Doolittle et al., 2023).

Therefore, this study integrates constructivist learning theory with TAM to provide a more comprehensive explanation of students' learning outcomes in AI-assisted music teaching. This integration allows the research to examine not only how students accept and use AI technologies, but also how such usage facilitates active knowledge construction and ultimately improves learning performance in music education contexts.

**2.3 Immediate Disciplines**

This study examines key TAM constructs including facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use in explaining students' acceptance of AI-assisted music teaching (Venkatesh et al., 2003). Within this framework, facilitating conditions refer to the availability of technical infrastructure, institutional support, and learning resources that enable effective system use. Perceived ease of use reflects the degree to which students believe that using AI-assisted music teaching requires minimal effort, while perceived usefulness represents their belief that such systems can enhance learning efficiency and performance outcomes. These cognitive evaluations jointly shape students' affective responses, particularly their attitudes toward AI-assisted music teaching. A positive attitude subsequently strengthens behavioral intention, which in turn serves as a direct antecedent of actual system usage. Prior research confirms that perceived ease of use and perceived usefulness significantly influence both attitude and intention, while behavioral intention is a strong predictor of actual use behavior (Fokides & Daskalou, 2026).

From a constructivist learning perspective, learning outcomes are understood as the result of active, interactive, and contextual knowledge construction processes, rather than passive knowledge reception (Haleem et al., 2022). In AI-assisted music education environments, students engage in continuous practice, receive immediate feedback, and adjust their performance through iterative learning cycles, which collectively enhance knowledge construction and skill development. AI technologies further support this process by enabling personalized learning pathways and adaptive instructional support(Mhlongo et al., 2023).

By integrating both TAM and constructivist learning theory, this study explores how students' cognitive perceptions, behavioral intentions, and actual usage of AI-assisted music

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teaching systems collectively influence their learning outcomes in music education contexts (Caratiquit & Caratiquit, 2022). This integrated perspective provides a more comprehensive understanding of the mechanism linking technology acceptance to educational effectiveness.

**2.4 Theoretical Framework and Hypothesis development**

The conceptual framework integrates TAM and constructivist learning theory to explain AI-assisted music teaching effects on learning outcomes. Facilitating conditions influence perceived ease of use and usefulness (H1–H2). Perceived ease of use affects usefulness and attitude

**2.5 Research Hypotheses**

Based on the theoretical foundations of the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology, and constructivist learning theory, this study develops a conceptual framework to examine how facilitating conditions, perceived ease of use, perceived usefulness, attitude, intention, and actual use of AI-assisted music teaching influence students' learning outcomes. The Technology Acceptance Model provides a useful explanation of how learners form beliefs about new educational technologies and how these beliefs shape their attitudes and behavioral intentions. In the context of AI-assisted music teaching, students do not merely evaluate whether a technology is available; rather, they assess whether the technology is understandable, useful, accessible, and relevant to their learning needs. Therefore, perceived ease of use and perceived usefulness are central psychological mechanisms through which students develop acceptance of AI-based learning tools.

At the same time, the Unified Theory of Acceptance and Use of Technology emphasizes the importance of external support conditions in technology adoption. For university music students, the successful use of AI-assisted music teaching depends not only on individual willingness but also on the availability of digital infrastructure, institutional guidance, teacher support, platform stability, and learning resources. These facilitating conditions are particularly important in music education because music learning often involves practice, feedback, creativity, performance, and technical skill development. If students lack access to appropriate devices, software, internet connectivity, or instructional guidance, the potential benefits of AI-assisted learning may not be fully realized. Therefore, this study incorporates facilitating conditions as an important external antecedent of students' perceptions and acceptance of AI-assisted music teaching.

Constructivist learning theory further supports the proposed framework by emphasizing that learning outcomes are shaped through active participation, interaction, reflection, and knowledge construction. AI-assisted music teaching provides students with opportunities to engage in personalized practice, receive

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immediate feedback, explore musical ideas, and construct knowledge through repeated interaction with intelligent systems. In this sense, AI does not simply function as a technical tool; it can also serve as a learning environment that supports students' active engagement, self-regulated learning, and creative exploration. Therefore, the integration of TAM, UTAUT, and constructivist learning theory provides a more comprehensive explanation of how students' technology acceptance can be transformed into actual use and, ultimately, improved learning outcomes.

Facilitating conditions represent the extent to which students perceive that adequate technical infrastructure, institutional support, and instructional resources are available to support their use of AI-assisted music teaching systems. In AI-assisted music teaching, facilitating conditions may include access to intelligent music platforms, digital composition tools, AI-based accompaniment systems, online practice applications, automatic feedback systems, and teacher-provided guidance on how to use these tools effectively. When learners have access to stable devices, reliable internet connectivity, timely technical assistance, and sufficient instructional guidance, they are more likely to perceive the system as easy to use(Xia & Guo, 2025). This reflects the role of external support in reducing operational barriers and enhancing users' perceived control over technology usage. For music students, such support is especially important because AI-based music tools may involve multiple functions, such as pitch recognition, rhythm correction, music generation, score analysis, and performance evaluation. Without sufficient support, students may experience confusion or anxiety when interacting with these systems. Therefore:

H1: Facilitating conditions positively influence perceived ease of use.

Facilitating conditions also play an important role in shaping students' perceptions of the usefulness of AI-assisted music teaching(Jiang et al., 2025). When institutional and technical support is sufficient, students are better able to experience the functional benefits of the learning system, such as improved efficiency and learning effectiveness. In music education, the usefulness of AI-assisted teaching may be reflected in more accurate practice feedback, more flexible learning resources, more efficient skill correction, and more individualized learning paths. For example, students may perceive AI-assisted tools as useful when these tools help them identify performance mistakes, improve music theory understanding, practice independently, or enhance creative composition. As a result, they are more likely to recognize the technology as valuable for their academic performance. Therefore:

H2: Facilitating conditions positively influence perceived usefulness.

Perceived ease of use refers to students' belief that AI-assisted music teaching is simple to operate and requires minimal effort. When students experience fewer difficulties in using the system, they can focus more on learning content rather than technical issues(Dou

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& Feng, 2025). This is particularly relevant in music learning because students need to devote considerable cognitive and emotional resources to listening, performing, interpreting, and creating music. If the technology is complicated, students may shift their attention away from musical learning and become occupied with operational problems. By contrast, when AI-assisted music teaching tools are intuitive, clear, and responsive, students are more likely to experience them as supportive rather than burdensome. This improved learning experience enhances their ability to recognize the system's benefits, leading to stronger perceptions of usefulness. Therefore:

H3: Perceived ease of use positively influences perceived usefulness.

Perceived ease of use also influences students' attitudes toward AI-assisted music teaching. When learners find the system easy to use, they tend to feel more confident and less cognitively burdened during learning activities(Maričić et al., 2025). In music education, confidence is an important factor because students often face performance pressure, technical challenges, and emotional sensitivity in the learning process. If AI-assisted tools are perceived as easy to operate, students may feel that the technology can support their learning autonomy rather than increase their burden. This positive experience contributes to more favorable evaluations of the technology, while difficult systems may generate frustration and reduce acceptance. Therefore:

H4: Perceived ease of use positively influences attitude toward AI-assisted music teaching.

Perceived usefulness reflects the degree to which students believe that AI-assisted music teaching improves their learning performance(Davis et al., 1989). In this study, perceived usefulness is not limited to general academic efficiency; it also refers to students' belief that AI-assisted music teaching can help them improve musical skills, deepen understanding, strengthen practice quality, and enhance learning confidence. When students recognize clear benefits such as better understanding, improved efficiency, and enhanced academic achievement, they are more likely to develop positive attitudes toward using the system. This is because students tend to evaluate educational technologies more favorably when they perceive a direct connection between technology use and meaningful learning gains. Therefore:

H5: Perceived usefulness positively influences attitude toward AI-assisted music teaching.

Perceived usefulness is also a key determinant of students' intention to use AI-assisted music teaching. When learners believe that the technology can effectively enhance their learning outcomes, they are more motivated to adopt and continuously use it in their study process(Otto et al., 2024). In the context of music learning, students' intention to use AI-assisted tools may be strengthened when they believe that such tools can help them practice more efficiently, receive more timely feedback, and improve their performance or creative output. Therefore, perceived

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usefulness serves as a motivational belief that encourages students to move from positive evaluation to future use intention. Therefore:

H6: Perceived usefulness positively influences intention to use AI-assisted music teaching.

Attitude toward AI-assisted music teaching refers to students' overall evaluation of using AI technologies in music learning. When students hold positive attitudes toward the system, they are more likely to express willingness to use it in their learning activities(Liang & Reiss, 2025). A positive attitude may arise from students' belief that AI-assisted music teaching is interesting, innovative, helpful, and compatible with their learning habits. In contrast, negative attitudes may reduce their intention to adopt the technology. For example, students who perceive AI-assisted music teaching as impersonal, difficult, or irrelevant may be less willing to integrate it into their daily learning. Therefore:

H7: Attitude toward AI-assisted music teaching positively influences intention to use AI-assisted music teaching.

Intention to use AI-assisted music teaching reflects students' willingness to adopt AI-based learning tools, which directly leads to actual usage behavior(Alshammari et al., 2025). Students with stronger behavioral intentions are more likely to actively engage with AI-assisted learning systems and participate in learning activities consistently. This relationship is important because intention represents a bridge between psychological acceptance and behavioral implementation. In other words, students may perceive AI-assisted music teaching as useful and hold positive attitudes toward it, but actual learning improvement is more likely to occur when such intention is transformed into regular and meaningful use. Therefore:

H8: Intention to use AI-assisted music teaching positively influences use of AI-assisted music teaching.

Use of AI-assisted music teaching refers to students' actual engagement with AI technologies during music learning activities(Wiyono et al., 2025). Actual use may include practicing with AI feedback systems, using AI tools for music analysis, interacting with intelligent tutoring platforms, generating or revising musical materials, and receiving personalized learning support. From the perspective of constructivist learning theory, students' learning outcomes are enhanced when they actively interact with learning environments and construct knowledge through experience. When students actively interact with these systems, they are more likely to construct knowledge effectively through participation and experience, which enhances their academic performance and learning outcomes. Therefore:

H9: Use of AI-assisted music teaching positively influences students' learning outcomes.

Perceived usefulness also has a direct impact on students' learning outcomes(Maamor et al., 2024). When learners perceive AI-assisted music teaching as beneficial, they are more likely to invest effort and engage meaningfully in learning tasks(Wiyono et al., 2025). This increased engagement

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supports knowledge construction and ultimately improves academic performance. In addition, students who perceive AI-assisted music teaching as useful may develop stronger learning motivation, greater confidence, and more active self-regulation. These psychological and behavioral responses may help them benefit from AI-assisted teaching even beyond actual usage frequency. Therefore:

H10: Perceived usefulness positively influences students' learning outcomes.

As shown in Table 1, the hypotheses developed in this study are systematically presented, outlining the proposed relationships among facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and students' learning outcomes in the context of AI-assisted music teaching. Overall, the proposed framework suggests that AI-assisted music teaching influences learning outcomes through both technological acceptance and learning engagement mechanisms. Facilitating conditions provide the external support necessary for students to access and operate AI-based learning systems; perceived ease of use and perceived usefulness shape students' cognitive evaluations of the technology; attitude and intention reflect their psychological acceptance; and actual use represents the behavioral pathway through which AI-assisted music teaching contributes to learning improvement. By integrating technology acceptance and constructivist learning perspectives, this study offers a structured explanation of how AI-assisted music teaching can support students' academic development in higher music education.

## 3. Research Methodology

### 3.1 Research Design

This study adopts a positivist research paradigm and a quantitative research design to systematically examine the relationships among key constructs in AI-assisted music teaching and students' learning outcomes. The positivist paradigm is appropriate as it emphasizes objective measurement, hypothesis testing, and statistical analysis of observable variables (Park et al., 2019). Accordingly, this study applies a cross-sectional survey method to collect empirical data from students, enabling the examination of relationships among facilitating conditions, perceived ease of use, perceived usefulness, attitude toward AI-assisted music teaching, intention to use, actual use behavior, and learning outcomes.

A structured questionnaire is used as the primary data collection instrument, and the research hypotheses are developed based on the Technology Acceptance Model and Constructivist Learning Theory. The deductive approach is adopted to test the proposed theoretical model using empirical data (Casula et al., 2021). Structural Equation Modeling (SEM) is employed to analyze both measurement and structural relationships among variables, allowing for simultaneous testing of multiple hypotheses. Overall, this quantitative research design ensures rigorous hypothesis testing and provides

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empirical evidence to validate the proposed conceptual framework.

**3.2 Research Tools**

The primary data collection instrument of this study is a structured questionnaire designed based on well-established measurement scales from prior research, with appropriate modifications to fit the context of AI-assisted music teaching. The questionnaire adopts a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), which is widely used in social science research for its simplicity, reliability, and effectiveness in capturing respondents' perceptions and attitudes.

The questionnaire consists of two sections. The first section collects respondents' demographic information, while the second section measures the key latent constructs of the study, including facilitating conditions, perceived ease of use, perceived usefulness, attitude toward AI-assisted music teaching, intention to use AI-assisted music teaching, use of AI-assisted music teaching, and students' learning outcomes.

Each construct is operationalized using validated multi-item scales adapted from previous studies to ensure content validity and conceptual consistency. Specifically, facilitating conditions are measured in terms of resource availability, knowledge, compatibility, and technical support (Ghanad, 2023). Perceived ease of use and perceived usefulness are adapted from the Technology Acceptance Model (Davis, 1989), focusing on accessibility, effort, and learning effectiveness (Ou et al., 2025). Attitude toward AI-assisted music teaching reflects learners' overall evaluation of AI in music learning, while intention to use and actual use capture behavioral readiness and engagement (Campbell et al., 2020). Students' learning outcomes are measured based on perceived learning effectiveness, improvement, and learning experience quality (Campbell et al., 2020).

All items are measured using a five-point Likert scale, ensuring consistency across constructs and enabling quantitative analysis through statistical techniques such as structural equation modeling. This design ensures reliability, validity, and comparability of the measurement model.

**3.3 Sampling and Data Collection**

This study targets university students majoring in music from different regions of China who have experience with AI-assisted music teaching. This population is appropriate because AI technologies are increasingly integrated into higher education, especially in skill-based disciplines such as music, where personalized instruction and continuous feedback are essential (Memon et al., 2020).

A purposive sampling technique was adopted to ensure respondents had relevant experience with AI-assisted learning tools. In addition, convenience sampling was used to recruit participants from accessible universities, improving data collection efficiency while maintaining relevance. This combined approach is widely used in educational technology research (Wolf et al., 2013).

The minimum sample size was calculated based on the 15:1 item-to-response ratio for structural equation modeling. With 27 measurement items, at least 405 responses were required. A total of 511 valid questionnaires were collected, meeting the recommended requirement and ensuring statistical reliability (Wu et al., 2022).

Data were collected through an online questionnaire distributed via university platforms and social media applications such as WeChat and QQ.

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Screening questions ensured respondents met inclusion criteria. After removing invalid responses, the final dataset was used for further quantitative analysis.

**3.4 Data Analysis**

The quantitative data in this study were analyzed using SPSS and SmartPLS to ensure accuracy, reliability, and robustness of the empirical results. A systematic multi-step procedure was adopted, including descriptive statistical analysis, measurement model evaluation, and structural model analysis. This approach is consistent with Partial Least Squares Structural Equation Modeling (PLS-SEM), which is widely used in educational technology research for testing complex relationships among latent variables (Al-Hail et al., 2023).

**3.4.1 Descriptive Statistical Analysis**

Descriptive statistical analysis was conducted to summarize respondents' demographic characteristics, including gender, age, year of study, and exposure to AI-assisted music teaching. This provides an overall profile of the sample and ensures its suitability for the research objectives.

In addition, mean and standard deviation were calculated to describe the distribution of key constructs, including facilitating conditions, perceived ease of use, perceived usefulness, attitude toward AI-assisted music teaching, intention to use, actual use, and students' learning outcomes. Mean values indicate the overall level of agreement, while standard deviation reflects response variability. This step also helps identify data distribution patterns and ensures suitability for further SEM analysis.

Overall, descriptive statistical analysis provides essential background information and serves as the foundation for subsequent measurement and structural model evaluation.

**3.4.2 Measurement Model**

The measurement model was evaluated to ensure the reliability and validity of the constructs before hypothesis testing. In this study, internal consistency reliability was assessed using Cronbach's alpha and composite reliability (CR). Values above 0.70 indicate acceptable reliability (Shea et al., 2022).

Convergent validity was examined using factor loadings and average variance extracted (AVE). Factor loadings above 0.70 and AVE values above 0.50 indicate adequate convergence. Discriminant validity was assessed using the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT), where HTMT values below 0.90 confirm construct distinctiveness (Cooksey, 2020).

These procedures ensure that all measurement scales used in this study are both reliable and valid for further structural analysis.

**3.4.3 Structural Model**

After validating the measurement model, the structural model was analyzed to test the hypothesized relationships among constructs. Path coefficients were estimated using SmartPLS, and their significance was assessed through bootstrapping with 5,000 resamples. A p-value below 0.05 indicates a statistically significant relationship (Hair et al., 2021).

In addition, the coefficient of determination ($R^2$) was used to evaluate the explanatory power of the model, while effect size ($f^2$) assessed the contribution of each predictor. Predictive relevance ($Q^2$) was examined using the blindfolding procedure, where values greater than zero indicate acceptable predictive capability.

Overall, the structural model analysis provides empirical evidence for testing all hypotheses and evaluating the explanatory strength of the proposed research model on AI-assisted music teaching and students' learning

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outcomes.

## 4. Results

### 4.1 Descriptive Statistics

A total of 511 valid responses were obtained and included in the final analysis, providing a sufficient sample size for subsequent statistical analysis. The demographic characteristics of the respondents are presented in Table 2. Among the participants, 58.1% were female and 41.9% were male, indicating a relatively balanced gender distribution, which enhances the representativeness of the sample and reduces potential gender bias.

In terms of age distribution, the majority of respondents were between 21 and 23 years old (46.6%), followed by those aged 18–20 (30.5%). This indicates that the sample primarily consists of undergraduate students in their early academic stages, who are generally more familiar with digital technologies and more likely to engage with AI-assisted learning tools.

Regarding academic level, respondents were distributed across different years of study, with junior students (26.6%) accounting for the largest proportion, followed by sophomores (23.7%) and seniors (23.1%). This relatively balanced distribution across academic levels enhances the diversity of the sample and improves its representativeness.

In terms of institutional background, participants were drawn from comprehensive universities (31.7%), normal universities (34.8%), and music or art universities (33.5%), indicating a well-balanced institutional representation. This diversity ensures that the findings are not limited to a single type of higher education institution.

Regarding the frequency of using AI-assisted music teaching, most respondents reported using it often (35.4%) or sometimes (30.9%), suggesting that the majority of participants had practical experience with AI-assisted learning tools. This ensures that respondents are capable of providing informed evaluations of the study constructs.

Overall, the demographic characteristics indicate that the sample is appropriate and sufficiently diverse for examining the influence of AI-assisted music teaching on students' learning outcomes. As shown in Table 2, the demographic profile of respondents is presented.

### 4.2 Measurement Model

The measurement model was evaluated by examining indicator reliability, internal consistency reliability, and convergent validity. The results show that the outer loadings of all items ranged from 0.708 to 0.846, exceeding the recommended threshold of 0.70, indicating satisfactory indicator reliability. Internal consistency reliability was assessed using Cronbach's alpha and composite reliability. The Cronbach's alpha values ranged from 0.745 to 0.824, while composite reliability values ranged from 0.839 to 0.884, all of which are above the recommended threshold of 0.70. These findings indicate that the measurement scales demonstrate good internal consistency. Convergent validity was further examined using average variance extracted (AVE). The AVE values ranged from 0.566 to 0.682, exceeding the acceptable threshold of 0.50, which confirms that each construct explains a sufficient proportion of variance in its indicators. Overall, the results confirm that the measurement model has satisfactory indicator reliability, internal consistency reliability, and convergent validity.

Discriminant validity was first

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assessed using the Fornell–Larcker criterion to determine whether each construct is empirically distinct from the others. The results show that the square root of AVE for each construct is greater than its correlations with other constructs. For example, facilitating conditions show a higher square root of AVE than its correlations with other variables, and the same pattern is observed for perceived usefulness, perceived ease of use, attitude, behavioral intention, actual use, and learning outcomes. This indicates that each construct shares more variance with its own measurement items than with other constructs, confirming adequate discriminant validity and conceptual distinction among variables.

Discriminant validity was further examined using the heterotrait–monotrait (HTMT) ratio. The results indicate that all HTMT values fall below the recommended threshold of 0.90, ranging from 0.503 to 0.859. The highest value is observed between attitude toward AI-assisted music teaching and intention to use AI-assisted music teaching, but it remains within the acceptable range. These findings further confirm that all constructs are empirically distinct and that there is no serious overlap among them. Overall, the results of both the Fornell–Larcker criterion and HTMT analysis demonstrate that the measurement model exhibits satisfactory discriminant validity, supporting the reliability and validity of the constructs used in this study.

**4.3 Structural Model Analysis**

he structural relationships.

The structural path analysis revealed that all hypothesized relationships were positive and statistically significant. Facilitating conditions were found to have a significant positive effect on perceived ease of use, indicating that when learners perceive sufficient external support, resources, and learning conditions, they are more likely to find AI-assisted music teaching systems easy to use. Facilitating conditions also significantly influenced perceived usefulness, suggesting that a supportive learning environment enhances learners' evaluation of the practical value of AI-assisted instruction.

Perceived ease of use was found to significantly affect perceived usefulness, indicating that when learners find AI systems easy to operate, they are more likely to perceive them as useful for learning purposes. In addition, perceived ease of use also had a significant positive effect on attitude toward AI-assisted music teaching, demonstrating that system simplicity contributes to more favorable learner attitudes.

Perceived usefulness was identified as a key antecedent variable in the model. It significantly influenced attitude toward AI-assisted music teaching, indicating that learners who perceive AI tools as beneficial are more likely to develop positive attitudes toward their use. Perceived usefulness also had a significant positive effect on intention to use AI-assisted music teaching, suggesting that perceived practical benefits directly motivate learners' willingness to adopt AI tools. Furthermore, perceived usefulness significantly influenced students' learning outcomes, indicating that learners who perceive higher utility from AI systems tend to achieve better academic performance.

Attitude toward AI-assisted music teaching was also found to be a strong predictor of behavioral intention. The results show that learners with more positive attitudes toward AI-assisted tools are more likely to intend to use them in their learning process. In turn, behavioral intention significantly

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influenced actual use of AI-assisted music teaching, confirming that intention plays a crucial role in translating psychological willingness into real behavioral engagement.

Finally, actual use of AI-assisted music teaching was found to have a significant positive impact on students' learning outcomes. This indicates that frequent and active engagement with AI-supported learning tools contributes directly to improved learning performance in music education. Overall, all hypothesized relationships were supported, confirming the robustness of the proposed structural model.

The explanatory power of the model was further examined using the coefficient of determination ($R^2$). The results showed that facilitating conditions explained 30.0% of the variance in perceived ease of use, indicating a moderate explanatory effect. When combined with perceived ease of use, facilitating conditions explained 44.2% of the variance in perceived usefulness, demonstrating that both environmental support and system usability jointly contribute to learners' perceived value of AI tools.

Perceived ease of use and perceived usefulness together explained 48.6% of the variance in attitude toward AI-assisted music teaching, indicating that learners' attitudes are largely shaped by their perceptions of usability and usefulness. Furthermore, perceived usefulness and attitude jointly explained 53.8% of the variance in behavioral intention, suggesting that cognitive evaluation and affective response together play a strong role in shaping learners' willingness to use AI-assisted systems.

Behavioral intention explained 37.3% of the variance in actual use behavior, indicating that intention is a meaningful but not exclusive predictor of real system usage. Finally, perceived usefulness and actual use jointly explained 41.7% of the variance in students' learning outcomes, suggesting that both cognitive evaluation and behavioral engagement contribute to academic performance improvements. Overall, the model demonstrates moderate explanatory power across all endogenous variables.

The effect size ($f^2$) analysis further clarified the relative contribution of each predictor variable. Facilitating conditions had a large effect on perceived ease of use, indicating that external support plays a critical role in shaping learners' perceptions of system usability. However, its effect on perceived usefulness was small, suggesting that its influence is more indirect.

Perceived ease of use had a medium effect on perceived usefulness, confirming that usability plays an important role in shaping perceived value. Its effect on attitude was relatively small, indicating a weaker but still meaningful influence. Perceived usefulness had a medium effect on attitude and a small effect on behavioral intention, highlighting its central but indirect role in shaping learner motivation.

Attitude toward AI-assisted music teaching had a large effect on behavioral intention, emphasizing its strong motivational role in determining learners' willingness to use AI tools. Behavioral intention had a large effect on actual use, confirming its critical role in translating intention into behavior. In addition, both perceived usefulness and actual use showed medium effects on students' learning outcomes, indicating that both perception and behavior contribute meaningfully to academic performance.

The predictive relevance of the model was assessed using the blindfolding procedure. All $Q^2$ values were greater than zero, indicating that

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the model has adequate predictive relevance for all endogenous constructs. This suggests that the model is not only explanatory but also capable of predicting future data patterns effectively.

Finally, the overall structural model results confirm a coherent and sequential mechanism linking facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and students' learning outcomes. Facilitating conditions and perceived ease of use indirectly influence learning outcomes through a chain of psychological and behavioral factors. Specifically, external support and system usability shape perceived usefulness, which then influences attitude and behavioral intention, ultimately leading to actual usage behavior and improved learning outcomes. This integrated pathway confirms the applicability of the Technology Acceptance Model in combination with learning theory in explaining AI-assisted music learning behavior.

**4.4 Conclusion**

The empirical results of the study examined the influence of AI-assisted music teaching on students' learning outcomes. First, descriptive statistical analysis was conducted to summarize respondents' demographic characteristics and the distribution of the study variables. The results indicated that the data were normally distributed and suitable for further analysis.

Next, the measurement model was assessed through reliability and validity analysis. The findings demonstrated satisfactory internal consistency, convergent validity, and discriminant validity, confirming that the measurement model was acceptable and the constructs were measured in a reliable and valid manner.

Subsequently, the structural model was evaluated to test the proposed hypotheses. The results revealed that facilitating conditions significantly influenced perceived ease of use and perceived usefulness. In addition, perceived ease of use and perceived usefulness significantly affected students' attitudes toward AI-assisted music teaching. Furthermore, perceived usefulness and attitude toward AI-assisted music teaching significantly influenced students' intention to use AI-assisted music teaching. The findings also indicated that intention to use AI-assisted music teaching significantly affected actual use behavior. Finally, both the use of AI-assisted music teaching and perceived usefulness significantly influenced students' learning outcomes. Overall, all proposed hypotheses were supported, indicating that the conceptual framework of the study was well supported by the empirical data.

These findings provide empirical evidence for understanding the adoption of AI-assisted music teaching and its impact on students' learning outcomes. The results also offer a solid foundation for further discussion of theoretical and practical implications, which will be presented in the following section.

**5. Discussion and Conclusions**

This study presents the discussion and conclusions of the study on the influence of AI-assisted music teaching on students' learning outcomes. Based on the empirical findings, it discusses the relationships among facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and learning outcomes. It further interprets the results in relation to the Technology Acceptance Model and Constructivist Learning Theory, and outlines their theoretical and practical implications. Finally, it addresses the study's limitations, provides suggestions for

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future research, and summarizes the overall conclusions.

**5.1 Theoretical Implications**

This study contributes to existing literature by extending the Technology Acceptance Model (TAM) and Constructivist Learning Theory within the context of AI-assisted music teaching.

First, the study extends TAM by confirming the central roles of facilitating conditions, perceived ease of use, and perceived usefulness in shaping students' attitudes toward AI-assisted music teaching. The findings demonstrate that facilitating conditions significantly influence both perceived ease of use and perceived usefulness, while perceived ease of use further enhances perceived usefulness and attitude. Perceived usefulness also directly strengthens students' attitudes, behavioral intention, and learning outcomes. These results reinforce the core TAM assumption that external conditions and cognitive beliefs jointly shape technology acceptance. More importantly, this study extends TAM by linking acceptance variables directly to learning outcomes, rather than focusing only on behavioral intention.

Second, the study refines the internal mechanism of TAM in AI-assisted learning contexts. The results indicate that attitude plays a stronger role than perceived usefulness in predicting behavioral intention, suggesting that affective evaluation is particularly important in music education settings. This finding extends prior TAM applications by highlighting that emotional acceptance may serve as a stronger bridge between cognitive beliefs and behavioral intention in creative and skill-based learning environments such as music education.

Third, this study contributes to Constructivist Learning Theory by confirming that actual use of AI-assisted music teaching significantly enhances students' learning outcomes. This supports the constructivist assumption that learning is strengthened through active engagement and interaction with learning tools. Importantly, the study extends constructivism by showing that knowledge construction is not only achieved through human interaction but also through interaction with AI systems. AI-assisted music tools provide real-time feedback, adaptive practice, and personalized learning support, which facilitate experiential learning and active knowledge construction.

Overall, this study integrates TAM and Constructivist Learning Theory into a unified framework that explains how technological perceptions lead to behavioral adoption and ultimately influence learning outcomes in AI-assisted music education.

**5.2 Practical Implications**

The findings provide practical implications for educators, institutions, and AI developers in music education.

For educators, the results highlight the importance of strengthening students' facilitating conditions by ensuring adequate technical support, training, and guidance in using AI-assisted music tools. Teachers should actively demonstrate how to use AI systems for tasks such as composition, pitch correction, rhythm training, and performance feedback. Such guidance can enhance students' perceived ease of use and perceived usefulness, thereby improving their attitudes and engagement.

Educators should also focus on enhancing system usability and learning integration. Since perceived ease of use strongly influences perceived usefulness and attitude, AI tools should be introduced in a structured and step-by-step manner. Teachers can reduce students' cognitive burden by providing tutorials, practice tasks, and

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guided demonstrations, ensuring that AI tools become accessible and meaningful learning instruments.

For institutions, the findings emphasize the importance of building strong digital infrastructure and providing continuous technical support. Institutions should ensure stable access to AI-assisted music platforms and offer professional training programs for both teachers and students. A supportive institutional environment can significantly improve students' acceptance and actual use of AI-assisted music teaching systems.

For AI developers, the study highlights the need to improve usability, personalization, and educational functionality. Systems should provide real-time feedback, adaptive learning pathways, and user-friendly interfaces. In addition, integrating interactive features such as performance tracking and learning analytics can further enhance user engagement and learning effectiveness.

Overall, successful implementation of AI-assisted music teaching requires coordinated efforts among educators, institutions, and technology developers.

**5.3 Limitations and Future Research**

Several limitations should be acknowledged.

First, the study adopts a cross-sectional design, which limits the ability to establish causal relationships. Although significant relationships were identified, students' perceptions and behaviors may change over time with increased experience in AI-assisted music learning.

Second, the study relies on self-reported data, which may introduce response bias. Students' evaluations of their learning outcomes and technology use may not fully reflect actual behavior.

Third, the sample is limited to university students exposed to AI-assisted music teaching, which may restrict generalizability to other populations such as secondary school students or professional musicians.

Fourth, although the model integrates key TAM and constructivist variables, other potential factors such as digital literacy, learning motivation, and prior musical experience were not included.

Finally, the study focuses on general AI-assisted music teaching rather than specific AI platforms, which may vary in functionality and effectiveness.

Future research should adopt longitudinal designs, expand sample diversity, include additional psychological and contextual variables, and explore different AI music learning systems. Mixed-method approaches such as interviews or case studies are also recommended to deepen understanding of learning processes.

**5.4 Conclusion**

This study examined the influence of AI-assisted music teaching on students' learning outcomes by integrating the Technology Acceptance Model and Constructivist Learning Theory. The findings indicate that facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use all play important roles in shaping learning outcomes.

Specifically, facilitating conditions enhance perceived ease of use and perceived usefulness, which in turn influence students' attitudes and behavioral intention. Behavioral intention significantly predicts actual use, and actual use, together with perceived usefulness, significantly improves learning outcomes. These results confirm that students' acceptance of AI-assisted music teaching is a key mechanism for improving learning performance.

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The study extends TAM by linking acceptance factors to learning outcomes and enriches Constructivist Learning Theory by demonstrating the importance of active engagement with AI systems. It also provides practical guidance for improving AI-assisted music teaching implementation in higher education.

Despite certain limitations, this study offers valuable theoretical and practical insights into AI-assisted music teaching and provides a foundation for future research on AI-supported music education.

**6. New Knowledge Contribution**

First, it extends the traditional scope of TAM by moving beyond behavioral intention and actual use to include students' learning outcomes as a core dependent variable. While previous TAM-based studies have primarily focused on explaining technology acceptance behavior, this research demonstrates a complete causal chain from facilitating conditions to cognitive perceptions (perceived ease of use and perceived usefulness), then to affective response (attitude), behavioral response (intention and actual use), and ultimately to educational outcomes. This extension provides a more comprehensive explanatory model that connects technology acceptance directly with educational effectiveness, thereby enriching TAM's applicability in AI-enhanced learning environments.

Second, this study contributes to a more nuanced understanding of how AI-assisted music teaching functions in higher education by revealing the differentiated roles of cognitive and affective factors. The findings show that perceived usefulness not only directly influences behavioral intention but also exerts a significant direct effect on learning outcomes, highlighting its dual pathway of influence. In contrast, attitude plays a particularly strong mediating role between cognitive beliefs and behavioral intention, suggesting that emotional evaluation is especially critical in creative and performance-based disciplines such as music education. This insight refines existing TAM applications by emphasizing that in artistic learning contexts, emotional acceptance may be as important as functional evaluation in shaping technology adoption behavior.

Third, the study supports the constructivist view that knowledge is actively constructed through interaction and experience. However, this study extends the theory further by showing that knowledge construction is not limited to human-to-human or learner-to-environment interaction but also includes learner-to-AI interaction. AI systems provide adaptive feedback, real-time performance evaluation, and personalized learning pathways, which collectively facilitate iterative learning processes and deepen students' active knowledge construction. This finding expands the theoretical boundaries of constructivism in the context of intelligent and data-driven learning environments.

Finally, this research contributes a context-specific theoretical integration model for AI-assisted music education in non-Western higher education settings, particularly within Chinese university contexts. By incorporating facilitating conditions as a foundational external factor and linking them systematically with psychological and behavioral constructs, the study provides a structured explanation of how institutional support and technological infrastructure indirectly shape learning outcomes.

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**Appendix**

**Table 1 Hypothesis development statement**

| | |
|---|---|
| H1 | Facilitating conditions positively influence perceived ease of use. |
| H2 | Facilitating conditions positively influence perceived usefulness. |
| H3 | Perceived ease of use positively influences perceived usefulness. |
| H4 | Perceived ease of use positively influences attitude toward AI-assisted music teaching. |
| H5 | Perceived usefulness positively influences attitude toward AI-assisted music teaching. |
| H6 | Perceived usefulness positively influences intention to use AI-assisted music teaching. |
| H7 | Attitude toward AI-assisted music teaching positively influences intention to use AI-assisted music teaching. |
| H8 | Intention to use AI-assisted music teaching positively influences use of AI-assisted music teaching. |
| H9 | Use of AI-assisted music teaching positively influences students' learning outcomes. |
| H10 | Perceived usefulness positively influences students' learning outcomes. |

**Table 2. Demographic Profile of Respondents**

| Information and options | Frequency | Percent (%) |
|---|---|---|
| **Gender** | | |
| Male | 214 | 41.9 |
| Female | 297 | 58.1 |
| **Age** | | |
| 18–20 | 156 | 30.5 |
| 21–23 | 238 | 46.6 |
| 24–26 | 92 | 18 |
| Above 26 | 25 | 4.9 |
| **Year of Study** | | |
| Freshman | 85 | 16.6 |
| Sophomore | 121 | 23.7 |
| Junior | 136 | 26.6 |

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| | | |
|---|---|---|
| Senior | 118 | 23.1 |
| Postgraduate | 51 | 10 |
| **Frequency of Using AI-assisted Music Teaching** | | |
| Rarely | 72 | 14.1 |
| Sometimes | 158 | 30.9 |
| Often | 181 | 35.4 |
| Very often | 100 | 19.6 |
| **Total** | 511 | 100 |

(Source: Ma Long)

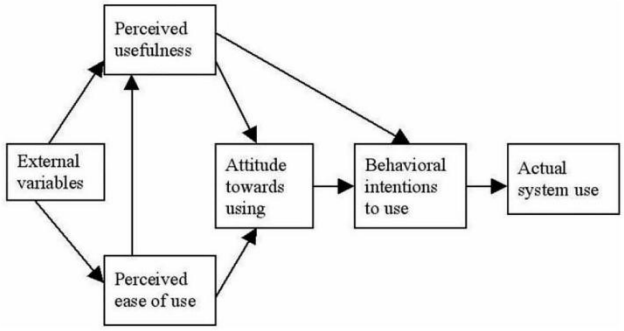



**Figure 1. Conceptual Model of Digital Intelligence-Driven Personalized Learning**
(Source: Davis et al. (1989))

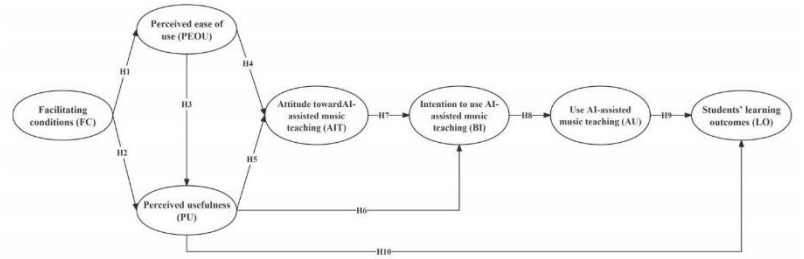



**Figure 2. Conceptual framework**

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