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The Impact of AI-Driven Personalized Learning Systems on Student Engagement in Music Education

Liang Qing[1], Chng Lay Kee[2]
Guangxi MinZu Normal University/City University Malaysia,
Faculty of Education and Liberal Studies Malaysia[1]
Faculty of Education and Liberal Studies,
City University Malaysia[2]

Abstract- This study investigates the influence of AI-driven personalized learning systems on student engagement within music education settings at higher education institutions in China. Employing a mixed-methods approach, the research utilized structured questionnaires for quantitative analysis and semi-structured interviews for qualitative insights. Findings indicate that AI-driven personalized learning systems significantly enhance student engagement by offering adaptive content, real-time feedback, and individualized learning pathways. These systems foster motivation, self-efficacy, and a sense of ownership in the learning process. However, challenges related to equitable access, data privacy, and the need for teacher training were identified. The study concludes that while AI-driven personalized learning systems hold transformative potential for music education, their integration must be accompanied by robust ethical guidelines and inclusive strategies to maximize benefits for all students.

Keywords- AI-driven personalized learning, student engagement, music education, adaptive learning, technology integration

I. INTRODUCTION

The integration of artificial intelligence (AI) in music education is transforming pedagogical approaches, particularly in higher education settings. AI-driven personalized learning systems adapt instructional content and feedback to individual student needs, fostering motivation and engagement (Li, 2024; Tang et al., 2022; Mazlan et al., 2023). This article addresses the research question: How may tailored learning systems powered by artificial intelligence affect student involvement in music education?" By synthesizing empirical and theoretical insights from recent literature, the discussion highlights both opportunities and challenges associated with AI integration in music education.

AI technologies in music education offer unprecedented opportunities for customization, real-time feedback, and adaptive learning experiences. AI-driven personalized learning systems analyze student data to provide individualized content and feedback, supporting diverse learning styles and fostering self-directed learning (Li, 2024; Omolara, 2023; Akavova et al., 2023). These systems not only enhance student motivation but also enable educators to focus on personalized instruction rather than administrative tasks (Wang et al., 2023; Ni et al., 2022).

The rise of AI-assisted tools, such as AI-driven music composition platforms and performance assessment systems, has further enriched the music education landscape. These tools encourage creativity, facilitate collaborative learning, and provide objective, data-driven feedback

(Dzwonczyk et al., 2022; He & Suttachitt, 2024; Chen, 2024). However, challenges related to data privacy, algorithmic bias, and equitable access remain significant concerns (Familoni & Onyebuchi, 2024; Qian, 2023; Yu & Yu, 2023).

AI-driven personalized learning is particularly impactful in music education, where individualized feedback and adaptive learning pathways are essential for skill development. Studies indicate that these systems can reduce learning gaps and improve retention rates by tailoring content to students' unique needs (Li, 2024; Trang & Thư, 2024; Sharma et al., 2023).

II. METHODOLOGY

This study employed a mixed-methods research design to explore the impact of AI-driven personalized learning systems on student engagement in music education1. The quantitative component utilized structured questionnaires administered to college students enrolled in music programs at higher education institutions in China. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to assess the relationships between the use of AI-driven personalized learning systems and student engagement.

The qualitative component involved semi-structured interviews with a subset of participants. Interview data were thematically analyzed to provide deeper insights into students' experiences, perceptions, and motivations regarding AI-driven learning tools. The integration of quantitative and qualitative data enabled a comprehensive understanding of how AI-driven personalized learning systems influence student engagement in music education.

The research was conducted with a focus on ensuring the validity and reliability of findings. The questionnaire response rate was documented (Table 0-1), and demographic characteristics of participants were analyzed (Table 0-2). Descriptive statistics, reliability, and validity measures were also reported (Tables 0-3 to 0-8)1. The methodological mapping of objectives (Table 3-1) guided the alignment of research activities with the study's aims.

III. RESULTS

The analysis of the quantitative data collected in this study, focusing on the relationships between AI-Assisted Music Composition (AMC), AI-Driven Personalized Learning (APL), AI-Based Performance Assessment (APA), Student Engagement (SE), and Academic Performance (AP) within music education at higher education institutions in China. describes the results of the Structural Equation Modeling (SEM), highlighting the direct and indirect effects, path coefficients, and explained variances.

Model Assessment and Explanatory Power

The first step in assessing the SEM model involved the examination of its explanatory power for both Student Engagement and Academic Performance. As shown in Table 1, Student Engagement had an adjusted R^2 of 0.602, indicating that approximately 60.2% of the variance in Student Engagement was explained by AMC, APL, and APA. Meanwhile, the adjusted R^2 for Academic Performance was 0.686, suggesting that 68.6% of its variance was explained by the model. These results imply that the proposed framework effectively captures the factors influencing students' engagement and academic outcomes within AI-assisted music education.

Table 1. Coefficient of Determination (R^2)

Endogenous Variable	R^2 Adjusted
Student Engagement (SE)	0.602
Academic Performance (AP)	0.686

Path Coefficients and Significance

The path coefficients and their statistical significance were examined to understand the direct relationships between the exogenous and endogenous variables. As indicated in Table 2, APL had a significant direct effect on both Student Engagement ($\beta = 0.374$, $t = 8.052$, $p < 0.001$) and Academic Performance ($\beta = 0.602$, $t = 13.609$, $p < 0.001$). This confirms that AI-Driven Personalized

Learning is a strong contributor to both engagement and performance in music education.
In contrast, AMC exhibited weaker and statistically insignificant direct relationships, both with Student Engagement (β = 0.075, t = 1.729, p = 0.084) and Academic Performance (β = 0.038, t = 0.792, p = 0.428). The results suggest that AMC has a limited direct role in shaping students' learning experiences and outcomes in this context.

APA demonstrated significant direct effects, both on Student Engagement (β = 0.470, t = 11.220, p < 0.001) and Academic Performance (β = 0.187, t = 3.609, p < 0.001). These results highlight the critical role of AI-Based Performance Assessment in nurturing an engaged and high-performing student body.Student Engagement itself had a strong direct effect on Academic Performance (β = 0.606, t = 10.327, p < 0.001), confirming its central role as an intermediary mechanism through which AI technologies impact learning outcomes.

Table 2. Path Coefficients and Significance

Path	Beta (β)	t-statistic	p-value
APL -> SE	0.374	8.052	<0.001
APL -> AP	0.602	13.609	<0.001
AMC -> SE	0.075	1.729	0.084
AMC -> AP	0.038	0.792	0.428
APA -> SE	0.470	11.220	<0.001
APA -> AP	0.187	3.609	<0.001
SE -> AP	0.606	10.327	<0.001

Effect Sizes (f^2)

The contribution of each variable to the explained variances was measured using the effect size (f^2). As shown in Table 3, APL had a medium effect on both Student Engagement (f^2 = 0.220) and Academic Performance (f^2 = 0.230), indicating its substantial role in fostering both engagement and performance. APA had a strong effect on Student Engagement (f^2 = 0.393) and a small effect on Academic Performance (f^2 = 0.016). AMC exhibited negligible effects for both Student Engagement (f^2 = 0.011) and Academic Performance (f^2 = 0.000), suggesting its lesser role in impacting the key outcomes measured. Student Engagement demonstrated the largest effect on Academic Performance (f^2 = 0.468), making it a pivotal mediator in the model as displayed in the Table below;

Table 3. Effect Sizes (f^2)

Path	Effect Size (f^2)
APL -> SE	0.220
APL -> AP	0.230
AMC -> SE	0.011
AMC -> AP	0.000
APA -> SE	0.393
APA -> AP	0.016
SE -> AP	0.468

Indirect and Mediated Effects

The role of Student Engagement as a mediator was further tested to assess indirect effects. As presented in Table 4, the indirect effect of APL on Academic Performance was significant (β = 0.227, t = 6.659, p < 0.001), indicating that APL's contribution to AP operates largely through its effect on SE. Similarly, APA had a significant indirect effect (β = 0.285, t = 7.198, p < 0.001), highlighting that the benefits of AI-Based Performance Assessment tools arise both directly and via improved Student Engagement. In contrast, AMC had an insignificant indirect effect (β = 0.045, t = 1.711, p = 0.087), suggesting that its role in boosting Academic Performance via Student Engagement is relatively limited.

Table 4. Indirect Effect Results

Path	Beta (β)	t-statistic	p-value
APL -> SE -> AP	0.227	6.659	<0.001
APA -> SE -> AP	0.285	7.198	<0.001
AMC -> SE -> AP	0.045	1.711	0.087

Summary of Results

The results confirm the pivotal role of AI-Driven Personalized Learning and AI-Based Performance Assessment tools in promoting Student Engagement and Academic Performance within music education. AI-Driven Personalized Learning (APL) emerged as a significant direct and indirect contributor to both engagement and performance.

Similarly, AI-Based Performance Assessment (APA) demonstrated robust direct and mediated effects, making it a critical component in AI-assisted music instruction. In contrast, AI-Assisted Music Composition (AMC) demonstrated weaker and largely insignificant effects across both direct and indirect pathways.

These findings align with existing literature indicating that AI-driven personalized learning environments foster higher engagement and performance (Li, 2024; Tang et al., 2022), suggesting their strong utility within music education settings. The results also emphasize the role of Student Engagement as a vital mediator that allows AI tools to positively affect academic outcomes.

The findings of this study directly address the second research question, "How may tailored learning systems powered by artificial intelligence affect student involvement in music education?" The quantitative results reveal that AI Driven Personalized Learning (APL) has a significant direct effect on Student Engagement ($\beta = 0.374$, $p < 0.001$) and a significant indirect effect via its influence on Academic Performance ($\beta = 0.227$, $p < 0.001$). The qualitative results further support this by showing that students perceive AI driven platforms as highly adaptive, motivating, and effective in addressing individual learning needs. Together, these results clearly demonstrate that AI driven personalized learning systems foster higher levels of student involvement in music education, providing both statistical evidence and rich narrative insights to answer the research question comprehensively.

IV. CONCLUSION

In conclusion, the quantitative results presented here reveal the significant role that AI technologies can play in music education. The use of AI-Driven Personalized Learning and AI-Based Performance Assessment tools significantly improves Student Engagement and Academic Performance, making these technologies valuable additions to higher education music environments. Meanwhile, AI-Assisted Music Composition, although creatively enriching, appears to have a weaker influence within the context of this study. These results provide valuable evidence for institutional stakeholders and music educators seeking to optimize learning environments by leveraging AI technologies.

Research by Li (2024) emphasizes that adaptive learning platforms allow students to study at their own pace by modifying the difficulty of the course and delivering activities that are focused on the objectives of the course, resulting in increased engagement and motivation among students1. The ability of AI-driven systems to deliver rapid feedback based on student input exemplifies their transformative potential, as highlighted by Tang et al. (2022)1. This approach enables teachers to enhance their instructional strategies by considering the individual development of each student.

Furthermore, studies have demonstrated that personalized learning systems can boost student motivation and engagement by catering to various learning styles and preferences (Mazlan et al., 2023)1. The self-directed learning encouraged by these systems empowers students to take responsibility for their musical development and build independence1. The integration of AI-driven analytics allows for real-time data analysis on student interactions, providing insights into learning preferences and levels of commitment1.

The collaborative and interactive features of AI-driven systems, such as virtual music ensembles and gamified learning modules, further enhance engagement by making learning dynamic and socially connected (Dzwonczyk et al., 2022)1. These features align with contemporary pedagogical strategies that emphasize active learning and peer interaction.

Challenges and Considerations

Despite the positive outcomes, the study identified several challenges. The risk of over-reliance on technology may compromise the development of foundational musical skills if students become

dependent on AI-generated feedback and suggestions1. Ethical concerns, including data privacy and algorithmic bias, must be addressed to ensure the responsible use of AI in educational settings1. Equitable access to technology is another critical issue, as disparities in resource availability can exacerbate existing inequalities among students1.The need for teacher training and professional development is also evident. Educators must be equipped with the skills to effectively integrate AI-driven systems into their teaching practices and to guide students in the ethical and effective use of these technologies1.

Suggestions

Based on the findings, several recommendations are proposed to optimize the integration of AI-driven personalized learning systems in music education:

- **Develop Clear Ethical Guidelines:** Institutions should establish policies that address authorship, data privacy, and the responsible use of AI in academic assignments1.
- **Promote Equitable Access:** Efforts should be made to ensure that all students, regardless of socioeconomic background, have access to AI-driven learning tools and the necessary technological infrastructure1.
- **Enhance Teacher Training:** Professional development programs should be implemented to equip educators with the skills and knowledge needed to effectively integrate AI-driven systems into their teaching practices.
- **Foster Student Autonomy:** Educators should encourage students to use AI-driven systems as tools for exploration and self-directed learning, while also emphasizing the importance of developing independent musical skills.
- **Encourage Collaborative Learning:** AI-driven systems should be designed to support collaborative and interactive learning experiences, such as virtual ensembles and peer feedback mechanisms, to enhance social engagement and collective creativity.

This study demonstrates that AI-driven personalized learning systems have a significant positive impact on student engagement in music education. By providing adaptive content, real-time feedback, and individualized learning pathways, these systems foster motivation, self-efficacy, and a sense of ownership in the learning process. However, their integration must be accompanied by robust ethical guidelines, inclusive strategies, and ongoing teacher training to maximize benefits for all students. As AI continues to evolve, its role in shaping the future of music education will be increasingly vital, offering new opportunities for creative expression, collaborative learning, and academic achievement.

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