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The Impact of Artificial Intelligence (AI) Integration on Student Engagement and Learning Outcomes of Tertiary Physical Education Students

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Abstract

Artificial intelligence (AI) has shown a unique ability to tailor and enhance personalized learning experiences. However, its application in physical education is limited. This study aims to investigate the effect of the AI-driven application on the learning outcome and student engagement among physical education students in higher education. A quasi-experimental two-group design was used to determine differences between pre-test and post-test scores. Standardized tests that measured musculoskeletal strength and endurance were utilized. The Utrecht Work Engagement Scale for Students (UWES-9S) assessed student engagement. For eight weeks, the experimental group (EG) had an AI-driven physical activities while the control group (CG) followed the usual PE class. Post-test scores showed the experimental group significantly improved the learning outcome ($p<0.001$). Engagement scores were also significantly higher in EG ($p < 0.01$). Consequently, The CG showed a significant decrease in student engagement while the increase in learning outcome is not statistically significant. These findings suggest that AI-driven applications positively affect students' physical fitness and engagement. Further research is recommended to fully implement AI in classrooms, addressing student and teacher literacy and ethical concerns to maximize its potential in the PE curriculum.

Keywords: Artificial Intelligence (AI), physical fitness, student engagement, learning outcome, tertiary education

INTRODUCTION

As the year 2023 progresses, educators and institutions alike are on the brink of a technological renaissance, with AI-driven innovations rapidly infiltrating the educational system and bringing in a new era of possibilities for improving the learning experience and promoting academic performance (Bahroun et al., 2022; Lee & Lee, 2021). The unique ability of AI to personalize learning experiences, seamlessly adapt to individual needs, and optimize instructional strategies highlights AI's potential in education (Hassan et al., 2021).

Despite the rapid integration of AI in numerous educational settings, and the presence of potential AI technologies, the field of physical education, characterized by its hands-on approach and a strong emphasis on direct human interaction, has experienced limited adoption of AI-enhanced teaching methods (Lee & Lee, 2021). This contrast prompts a significant question and highlights a notable gap within the current educational research and practice. While AI has shown the ability to tailor and enhance personalized learning experiences, its application in the context of exercise-based learning has been largely unexplored (Li & Li, 2022; Lee & Lee, 2021; Li & Wang, 2021).

Recognizing the vital role of physical education in developing students' motor skills, promoting lifelong physical activity participation, and fostering overall well-being (UNESCO, 2015; Bandeira et al., 2022), along with the World Health Organization's (WHO) emphasis on the role of physical activity in health and cognitive function (WHO, 2021), the promise of AI in enhancing physical education curriculum becomes pivotal. The ability of AI to personalize learning experiences (Hassan et al., 2021) is inevitably linked to the goals of a physical education (PE) program, which, when well-designed, addresses diverse student needs, fosters active engagement, and instills critical

self-management skills (Dobson & Rawlings, 2023).

Furthermore, the critical importance of the current study is heightened by the dynamic landscape of educational technology adoption (Anggraeni, 2018; Holmes et al., 2019) which necessitates innovative strategies to engage students more effectively and optimize physical skill acquisition (Ouyang & Jiao, 2021; Hwang et al., 2020).

Thus, the aim to fill a critical gap in the literature by delving into the unexplored potentials of integrating AI-driven applications and technological tools in the domain of physical education (Lee and Lee, 2021; Li and Wang, 2021), with a particular focus on the PED012 course. This course focused on exercise-based fitness activities, directed on enhancing and sustaining the cardiorespiratory and musculoskeletal fitness of students.

METHOD

Subjects. The population of this study was composed of seventy (70) students from two randomly selected PE sections in Mindanao State University-Iligan Institute of Technology.

Research Instrument. The research employs a set of three distinct instruments to comprehensively assess various aspects of student engagement, learning outcomes, and the impact of AI-driven interventions. These instruments are described below:

1. Student Engagement. The primary instrument for gauging student engagement is the Utrecht Work Engagement Scale for Students (UWES-9S), a widely recognized tool originally formulated by Schaufeli (2003). The UWES-9S measures students' overall school engagement. It has established reliability and validity in previous research (Schaufeli et al., 2006; Carmona-Halty et al., 2019). The UWES-9 scale has been widely used in scientific literature with samples from various countries around the world, including Europe, Asia, Africa, the Americas, and Oceania (Schaufeli et al., 2017; Klassen et al., 2012, as cited by Domínguez-Salas et al., 2022).

2. Learning Outcome. The study assessed the learning outcomes of the respondents by evaluating their physical fitness levels, focusing on cardiovascular endurance, core strength, upper body strength, and lower body strength. To measure their performance, a battery of standardized physical fitness tests was employed. These tests are Harvard Step test; Extended-Arm Hang Test (or straight arm hang, dead hang) measures upper body strength and endurance, particularly grip strength; Plank Test for core muscle strength; and wall squat test to measure lower body muscular strength and endurance.

3. AI-Driven Intervention Program. The study integrated AI-driven applications, such as Active Arcade, Tuby, Sports Party, and Jumpr, into the activities of the existing physical education (PE) class. These activities were carefully planned to incorporate artificial intelligence (AI) tools into the curriculum, with the overarching goal of increasing student engagement and improving fitness performance. Each application offered unique features aligned with the four components of fitness. For instance, Active Arcade utilized motion-based gaming with activities like "Laser Dodge" to enhance cardiovascular endurance through body movement detection. Tuby emphasized exercises targeting muscular strength, power, and core stability, such as jumps, planks, and abdominal crunches. Jumpr focused on plyometric activities to build explosive lower-body strength, while Sports Party featured sports-inspired games that fostered teamwork and skill-building.

   The programming of activities was tailored to match specific fitness components on designated days, following key training principles such as specificity, progressive overload, variety, and individualization. For example, on Day 1, activities targeting cardiovascular endurance were programmed using "Laser Dodge" (4 sets of

2 minutes) from Active Arcade. Meanwhile, Tuby's core and power exercises were incorporated for muscular strength and endurance sessions. Progressive overload was applied by increasing the intensity or reducing rest intervals over time, ensuring gradual improvement.

Data Gathering. The study involved randomly assigning participants to control and experimental groups, with both groups completing informed consent forms and the Physical Activity Readiness Questionnaire (PAR-Q) to ensure safety and eligibility. Physical fitness tests were conducted to measure the learning outcome, along with the Utrecht Work Engagement Scale for Students (UWES-9S) to assess engagement levels. The experimental group participated in an 8-week AI-driven program using applications such as Active Arcade, Tuby, Sports Party, and Jumpr, with activities specifically tailored to target fitness components. Post-tests and the UWES-9S were administered after the intervention to evaluate changes in physical fitness and engagement.

Ethical approval for the study was obtained from the Adamson University Ethics Review Committee under protocol number 2023-04-EDU-62, ensuring compliance with ethical research standards.

Statistical Analysis. Inferential statistics were employed to determine whether there are significant differences between the experimental and control groups concerning student engagement and physical fitness outcomes. The following statistical tests were utilized:

1. Independent Samples T-test was used to compare the mean scores in the learning outcome and student engagement between the experimental and control groups both before and after the AI-driven intervention.

2. Paired samples T-tests were conducted within each group (experimental and control) to compare the pre-intervention and post-intervention scores of both student engagement and learning outcomes. For student engagement, this analysis determined whether the intervention had a significant impact on engagement levels within each group. Similarly, for learning outcomes, the paired samples T-test will assess the significance of changes within each group.

RESULTS

Measured through fitness performance, the results of the study indicate that the integration of Artificial Intelligence (AI) into the curriculum significantly enhanced both student engagement and learning outcomes among tertiary physical education students. As shown in Table 1, within the experimental group, there was a substantial improvement in learning outcomes, with a mean difference of 31.21 between post-test and pre-test scores, which was statistically significant ($p \leq 0.001$). This finding highlights the effectiveness of the AI intervention in improving students' fitness performance.

Additionally, the experimental group experienced a significant increase in student engagement, with a mean difference of 0.49 ($p = 0.014$), suggesting that the use of AI fostered a more engaging and interactive learning environment. Conversely, the control group showed a smaller and statistically insignificant improvement in learning outcomes (mean difference = 4.68, $p = 0.063$) and a notable decline in engagement (mean difference = -0.41, $p \leq 0.01$), indicating potential disengagement in the absence of the AI-enhanced intervention.

Furthermore, between-group comparisons revealed significant differences favoring the experimental group (Table 2). In terms of post-test learning outcomes, the experimental group outperformed the control group with a mean difference of 46.14 ($p \leq 0.001$), emphasizing the effectiveness of the AI-enhanced curriculum in improving fitness performance. Similarly, post-test engagement scores were significantly higher in the experimental group compared to the control group, with a mean difference of 1.38 ($p \leq 0.001$), underscoring the role of AI in maintaining student interest and active

participation. These findings suggest that AI-driven applications have the potential to address common challenges in physical education, such as declining student engagement and limited improvements in fitness performance, by providing personalized feedback, gamified experiences, and real-time progress tracking.

Table 1

Paired Samples Test on the significant difference in between the pre and post-test scores of learning outcomes and student engagement in the control and experimental groups.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Experimental Group	POST_LO PRE_LO	31.21	33.17	5.61	19.82	42.60	5.57	34	***0.000
	POST_SE PRE_SE	0.49	1.12	0.19	0.12	0.87	2.59	34	*0.014
Controlled Group	POST_LO PRE_LO	4.68	14.41	2.44	0-.27	9.63	1.92	34	0.063
	POST_SE PRE_SE	-0.41	0.81	0.14	-0.69	-0.13	-2.99	34	**0.005

LEGEND: *Difference is significant at 0.05 level; **p≤0.01, ***p≤0.001

Table 2

Independent Samples Test on the significant difference in the pre and post-test scores of learning outcomes and student engagement between the control and experimental groups.

Dependent Variables		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
PRE_LO	Equal variances assumed	13.167	.001	2.30	68	.012	19.60952	7.55600	4.53176	34.68729
	Equal variances not assumed			2.30	47.85	*0.013	19.60952	7.55600	4.41596	34.80309
PRE_SE	Equal variances assumed	.977	.326	2.16	68	*0.035	.48254	.22390	.03575	.92933
	Equal variances not assumed			2.16	66.83	0.035	.48254	.22390	.03561	.92947
POST_LO	Equal variances assumed	19.908	.000	4.10	68	0.000	46.14286	9.23444	27.71581	64.56990
	Equal variances not assumed			4.10	43.88	***0.000	46.14286	9.23444	27.53055	64.75516
POST_SE	Equal variances assumed	1.530	.220	7.88	68	***0.000	1.38095	.17526	1.03123	1.73067
	Equal variances not assumed			7.88	64.13	0.000	1.38095	.17526	1.03085	1.73106

LEGEND: *Difference is significant at 0.05 level; **p≤0.01, ***p≤0.001 (2-tailed)

DISCUSSION

The study highlights the significant impact of integrating AI-driven applications into the PATHFIT 2 curriculum, emphasizing their effectiveness in enhancing both fitness performance and student engagement. The experimental group demonstrated substantial improvements in learning outcomes compared to the control group, with significant differences observed between pre-test and post-test scores. These findings underscore the ability of AI-driven interventions to provide a more effective, engaging, and personalized approach to physical education compared to traditional methods. The control group, which relied on conventional exercises, exhibited limited improvements, emphasizing the need for innovative strategies to maintain interest and promote consistent progress.

The success of the AI-driven interventions can be attributed to their personalized and adaptive features, which tailored exercise routines to individual fitness levels and provided real-time feedback. These systems effectively addressed common challenges in physical education, such as lack of variety and monotony, by offering diverse and interactive workout experiences. This aligns with previous research demonstrating that personalized fitness plans and immediate feedback foster better engagement and performance outcomes (Byrd et al., 2019; Mokmin, 2020; Rizvi, 2023). Additionally, the use of gamification and progress tracking in the AI applications helped sustain student motivation, making the sessions more enjoyable and productive (Kari et al., 2016; Dey, 2023). In contrast, the control group, which participated in traditional activities, experienced a decline in engagement, likely due to the repetitive and generalized nature of the exercises, as suggested by Cruz et al. (2021).

The results also highlight the transformative potential of AI in modernizing physical education by addressing limitations in conventional approaches, such as the absence of tailored feedback and adaptive programming. The experimental group's outcomes reflect the advantages of integrating technology to create a learning environment that actively responds to the unique needs and progress of students, ensuring sustained engagement and holistic development. This aligns with findings from Roshanaei et al. (2023) and Akavova et al. (2023), who emphasize that AI-driven programs offer opportunities for greater inclusivity and efficiency by leveraging interactive features and real-time adjustments.

While the study demonstrates the effectiveness of AI in fostering improved outcomes, it also reveals areas requiring further exploration. The

lack of significant change in long-term commitment and intrinsic motivation suggests that additional strategies, such as incorporating personalized goal setting and fostering peer collaboration, may enhance the deeper aspects of student engagement. This is consistent with the recommendations of Buçinca (2024) and Sankara Narayanan & Kumaravel (2024), who propose integrating social and collaborative elements into technology-mediated fitness interventions to build intrinsic motivation and a sense of autonomy.

These findings also have implications for addressing broader challenges in physical education, particularly the prevalence of inactivity among youth. By providing accessible and engaging exercise solutions, AI-driven applications can promote regular participation in physical activities and cultivate lifelong fitness habits. Moreover, the adaptability of these interventions makes them particularly suitable for addressing resource limitations in educational settings, as they require minimal equipment and can be tailored to diverse student needs (Bodemer, 2023; Su et al., 2024). However, ethical considerations, such as data privacy and the responsible use of AI, must be addressed through appropriate teacher training and student education, as emphasized by Alenezi (2023) and Chiu et al. (2023).

Therefore, the study confirms the effectiveness of AI-driven applications in enhancing learning outcomes and student engagement, demonstrating their potential to transform physical education. By leveraging personalized feedback, adaptive programming, and interactive features, these tools provide a comprehensive and engaging approach that addresses the limitations of traditional methods. However, to fully realize their potential, future research should focus on optimizing strategies for fostering intrinsic motivation and addressing ethical concerns. These efforts will ensure that AI-driven applications continue to serve as innovative and sustainable solutions in physical education.

CONCLUSION

The study emphasizes that the integration of AI-driven applications into the PATHFIT 2 curriculum significantly improved fitness performance and student engagement compared to traditional methods. While the control group exhibited limited gains in learning outcomes and experienced a decline in engagement, the experimental group achieved significant improvements. These findings underscore the effectiveness of AI-driven applications in addressing the limitations of traditional physical education programs by delivering personalized fitness plans, gamified activities, and real-time feedback. To enhance the impact of such interventions, it is recommended that teachers implement AI-driven applications to provide tailored exercises, track progress, and sustain student motivation through interactive and resource-efficient methods, while also considering the ethical concerns associated with the use of AI.

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