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Interdisciplinary Physical Education: A Solution for Fundamental Movement Skills and Numeracy Challenges in Elementary School Students

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ABSTRACT

The purpose of this study was to determine the effect of interdisciplinary physical education learning on the fundamental movement and numeracy skills of students. An experimental research method was implemented by integrating interdisciplinary physical education with mathematics. The implementation was carried out for 12 meetings within a period of 6 weeks using a randomized pre-test post-test control group design. The research population was the third-grade students, totalling 4 classes consisted of 135 students. The cluster random sampling technique was used to determine research samples. Class III-B, consisting of 34 students, was selected as Experimental Group 1 (taught by a teacher experienced in interdisciplinary PE). Class III-A, with 33 students, was selected as Experimental Group 2 (taught by a teacher not experienced in interdisciplinary PE) and Class III-C, with 33 students, was selected as the Control Group. The treatment program was implemented for 12 meetings in 6 weeks. The instruments were TGMD-2 and AKM Numeracy test level 2. The results of the study showed a significant increase in the fundamental movement skills of students in Experimental Group 1 of 17.529 (Sig. 0.00) and a significant increase in numeracy abilities of 23.823 (Sig. 0.00). Meanwhile for Experimental Group 2, there was a significant increase in the fundamental movement skills of students of 11.515 (Sig. 0.00) and a significant increase in numeracy abilities of 21.591 (Sig. 0.00). The results of this study concludes that this interdisciplinary physical education program is feasible to be implemented to address the problems in fundamental movement skills and numeracy abilities, particularly in classes taught by experienced teachers.

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INTRODUCTION

The past Covid-19 pandemic and current technological advancements have had a significant impact on various aspects of life in Indonesia, including education. While these developments have brought certain benefits, they have also led to negative consequences, such as a decline in the student knowledge and skills, commonly referred to as learning loss (Pier et al., 2021). The phenomenon of learning loss has had a considerable impact on student learning processes in Indonesia (Azevedo et al., 2021; Putri & Handayani, 2021).

In the context of physical education (PE), learning loss is associated with a decline in students' motivation to engage in movement-based learning (Junianto, 2022) This issue was further exacerbated by restrictions on social activities during the COVID-19 pandemic, which reduced students' opportunities and willingness to participate in physical activities (Kusdalinah et al., 2022; Suryoadji & Nugraha, 2021). In addition, rapid technological advancements have increased students' tendency to spend their free time using digital devices (Efendi & Widodo, 2021; Rini & Huriah, 2020), thereby promoting sedentary behavior.

From a developmental perspective, this shift in lifestyle directly affects the critical period of children's motor development, contributing to a decline in movement quality, particularly in fundamental movement skills (FMS), especially among elementary school students (Bakhtiar & Famelia, 2020; Oktarifaldi et al., 2024). FMS refers to basic motor skills, including locomotor, non-locomotor, and manipulative movements, which are essential for supporting effective movement in daily life (Barnett et al., 2016; Nesbitt & Bullard, 2021). Indeed, the development of FMS is a primary objective of PE learning at the elementary school level. However, the failure to optimize FMS development during this critical period has contributed to the classification of Indonesian students' motor skills as being in the "low" category, indicating the need for more adaptive pedagogical interventions within the PE curriculum (Ariyanto et al., 2020; Supriadi, 2019).

The impact of learning loss does not occur in isolation but extends to other cognitive domains, particularly numeracy literacy in mathematics. Numeracy refers to the ability to understand and use numbers and mathematical symbols, as well as to analyze information in order to solve practical problems in various daily life contexts (Mahmud & Pratiwi, 2019). The low level of students' numeracy has become a central concern of the Programme for International Student Assessment (PISA), whose findings indicate that 36 countries still have mathematical literacy performance below Level 2 (score < 420), which is considered below the minimum competency required to function effectively in daily life (OECD, 2023). The stagnation in students' mathematical literacy performance, as reflected in the PISA data, indicates a decontextualization of the learning process. This issue is critical, considering that numeracy, which is defined as the knowledge and skills to use numbers and symbols related to basic mathematics to solve practical problems in daily life (e.g., at home, in the workplace, and in civic participation) and to analyze information presented in various forms, as well as to interpret the results of such analysis to predict outcomes and make decisions, is an essential competence for all students (Ayuningtyas & Sukriyah, 2020).

The phenomenon described above requires urgent attention. The decline in students' learning motivation, both in terms of physical activity and mathematical numeracy, particularly at the elementary school level, must be addressed promptly. To this end, innovative approaches to teaching and learning are essential to stimulate student motivation and improve learning outcomes. One promising approach is the implementation of

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interdisciplinary learning, an innovative pedagogical concept that is increasingly recognized as essential in the 21st century but remains underutilized by physical education teachers in Indonesia (Budiman et al., 2024). The adoption of interdisciplinary learning is supported by a strong theoretical foundation. In contrast to conventional teaching approaches that compartmentalize knowledge into rigid subject boundaries, interdisciplinary learning integrates key concepts across disciplines through active and meaningful learning experiences. This approach encourages the integration of multiple subjects into project-based activities that connect and apply key concepts in a holistic manner (Abdi & Juniu, 2014).

In this study, physical education (PE) is integrated with mathematics, whereby movement-based activities performed by students during lessons are directly linked to numeracy learning. This approach enables mathematics instruction to become more contextual and applicable, as previous research has demonstrated the potential of interdisciplinary PE to effectively enhance additional domains integrated within it (Nopembri & Sugiyama, 2022). Such an innovative learning environment is expected to stimulate students' learning motivation while reducing the boredom often associated with traditional PE and mathematics instruction (Fuaddi et al., 2020). Through an interdisciplinary approach, the learning process can become more engaging, effective, and meaningful (Livstrom et al., 2019; Sunarti et al., 2020). For instance, one study demonstrated that interdisciplinary PE, implemented through the Sport Education Model, was able to synergize with mathematics instruction, successfully achieving the learning objectives of both subjects within a single PE lesson. Other studies have also reported the benefits and feasibility of interdisciplinary PE when integrated with subjects such as geography in the Czech Republic and Slovenia.

However, several challenges have been identified regarding the implementation of interdisciplinary learning programs. One study reported that academic expert surveys revealed issues related to curriculum integration. In addition, teacher surveys indicated that interdisciplinary teaching is rarely practiced, with nearly half of the teachers having no prior experience in integrating subjects, despite possessing substantial teaching experience. For example, 23 geography teachers who integrated geography with other subjects considered the integration of physical education and geography to be highly important. Similarly, 18 PE teachers who implemented interdisciplinary approaches emphasized their value in facilitating the simultaneous achievement of learning objectives across subjects. In contrast, teachers without prior experience in interdisciplinary teaching tended to perceive it as less important, citing a lack of meaningful connections between subjects. This finding indicates a limited understanding of interdisciplinary learning practices and policies (Vlček et al., 2019). This divergence in perceptions reflects not only limited teacher literacy regarding innovative pedagogical approaches but also highlights a critical research gap. If this issue is not addressed, it may contribute to a broader lack of confidence in the effectiveness of interdisciplinary PE. Moreover, survey findings indicate that interdisciplinary physical education remains rarely implemented in Indonesian schools at the elementary, junior high, and senior high levels (Budiman et al., 2024). This limited implementation is largely attributed to insufficient knowledge among physical education teachers regarding interdisciplinary teaching methods.

Therefore, this study was conducted to address issues related to students' fundamental movement skills (FMS) and numeracy competencies, while also filling the identified research gap by involving teachers with limited experience in implementing interdisciplinary PE. This study focused on third-grade elementary school students. This choice was based on the consideration that the learning process students experience during the early years of

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elementary school, particularly in physical education, may be less effective due to the impact of the Covid-19 pandemic, where all learning activities are conducted online. Furthermore, third grade represents a critical period for the consolidation of FMS, while students at this stage have already acquired basic numeracy skills. Therefore, integrating numeracy into interdisciplinary physical education is expected to be both feasible and effective, particularly in relation to foundational mathematical competencies.

METHODS

Research Design

This study employed a quantitative method with an experimental approach. A randomized pretest–posttest control group design was used to examine the effects of an interdisciplinary physical education (PE) program on students' fundamental movement skills (FMS) and numeracy abilities.

Participants

The participants consisted of third-grade students from SD Negeri Citeureup Mandiri 2, Cimahi City. A total of 135 students (76 females and 59 males), aged 8–9 years, from four classes participated in this study.

Sampling Procedures

Cluster random sampling was used to select the research sample. From the four third-grade classes (III-A, III-B, III-C, and III-D), three classes were randomly selected. These classes were then randomly assigned to either experimental or control groups. Class III-B (n = 34) was assigned as Experimental Group 1, Class III-A (n = 33) as Experimental Group 2, and Class III-C (n = 33) as the Control Group.

Materials and Apparatus

The instruments used in this study included the Test of Gross Motor Development-2 (TGMD-2) (Ulrich et al., 2000), with a reported reliability coefficient of 0,765, to measure students' fundamental movement skills (FMS). Students' numeracy abilities were assessed using the Grade III Numeracy Assessment (AKM Level 2), officially developed by the Indonesian government based on Pusmendik guidelines and standardized to ensure valid and reliable measurement (Sariyasa & Ardana, 2023).

Procedures

To ensure ethical research practices, the researchers obtained informed consent from parents or guardians, as well as approval from PE teachers and school administrators. Participants were then briefed on the procedures prior to data collection. A pretest was conducted to assess students' FMS during physical education lessons using the TGMD-2. One day later, a numeracy pretest was administered during mathematics lessons using digital devices (laptops and mobile phones). Following baseline data collection, the interdisciplinary PE intervention was implemented over 12 sessions, conducted twice per week during both physical education and mathematics lesson periods. After the intervention, posttests were administered to reassess students' FMS and numeracy abilities using the same instruments.

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Data Analysis

Data analysis was carried out using the Statistical Product and Service Solutions (SPSS) version 25 software. The statistical analysis began with a normality test using the Shapiro–Wilk test and a homogeneity test using Levene's statistic. Then parametric statistical tests (paired sample t-test) were employed with a significance level set at $\alpha = 0.05$. Furthermore, to identify which treatment was more effective, gain scores for both fundamental movement skills and numeracy were analyzed using ANOVA, followed by post-hoc testing with Tukey's test.

RESULTS

The results of the 12-session interdisciplinary physical education (PE) intervention are presented for both fundamental movement skills (FMS) and numeracy variables across the three groups. Table 1 summarizes the descriptive statistics of the pre-test and post-test scores for students' FMS and numeracy abilities.

Table 1. Descriptive Statistics of Student FMS and Numeracy Abilities

Variable	Group	N	Pre-test		Post-test	
			Mean	SD	Mean	SD
FMS	Experiment 1	34	78,24	9,30	95,76	10,42
	Experiment 2	33	78,73	9,15	90,24	10,22
	Control	33	77,58	8,07	87,79	6,61
Numeracy abilities	Experiment 1	34	55,51	14,10	79,34	12,75
	Experiment 2	33	53,03	15,06	74,62	14,59
	Control	33	54,09	14,61	64,01	14,26

The data presented in Table 1 indicate that, during the pre-test, both experimental groups demonstrated comparable fundamental movement skills (FMS) performance, with mean scores of 78.24 (Experimental Group 1) and 78.73 (Experimental Group 2), both categorized as "low." Following the intervention, FMS scores increased in both groups, with post-test means of 95.76 for Experimental Group 1 and 90.24 for Experimental Group 2, indicating an improvement to the "average" category.

Similarly, for numeracy abilities, the pre-test mean scores were 55.51 for Experimental Group 1 and 53.03 for Experimental Group 2. After the intervention, both groups showed notable improvements, with post-test mean scores increasing to 79.34 and 74.62, respectively.

Improvement of Student Fundamental Movement Skills (FMS)

Following the implementation of the interdisciplinary PE program, an improvement in students' FMS was observed. The results of the paired-sample t-test comparing pre-test and post-test FMS scores are presented in Table 2. Based on the results of the paired sample t-test in Table 2, it was found that the significance value (Sig.) for the improvement of students' fundamental movement skills (FMS) in both experimental groups was 0.000 ($p < 0.05$), indicating that H_o was rejected. This finding suggests that the interdisciplinary PE intervention had a statistically significant effect on students' FMS in both groups. The mean difference in Experimental Group 1 (taught by a teacher with prior interdisciplinary PE experience) between pre-test and post-test scores was −17.529, indicating an average increase of 17.529 points. In Experimental Group 2 (taught by a teacher without prior interdisciplinary PE experience), the mean difference was −11.515, reflecting an average increase of 11.515 points. These results indicate that both implementations of interdisciplinary PE contributed

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to improvements in students' FMS, with a greater increase observed in Experimental Group 1. For the comparison of FMS improvement across groups, the results of the ANOVA test are presented in Table 3.

Table 2. Results of The Paired Sample T-Test on Student Pre-Test and Post-Test FMS after Interdisciplinary PE Learning

		Paired Differences		Sig.
		Mean	Std. Deviation	(2 tailed)
Pair 1	Pre-test FMS (experiment 1) - Post-test FMS (experiment 1)	-17,529	7,879	,000
Pair 2	Pre-test FMS (experiment 2) - Post-test FMS (experiment 2)	-11,515	6,520	,000

Table 3. Results of The ANOVA Test on The Improvement of Student FMS

ANOVA

FMS Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1025.082	2	512.541	11.258	.000
Within Groups	4416.228	97	45.528		
Total	5441.310	99			

Based on the comparison of FMS gain scores across groups (Table 3), the significance value was found to be $p < 0.001$, indicating a statistically significant difference in FMS improvement among the groups. To further identify which groups differed significantly, a post-hoc Tukey test was conducted. The results of the Tukey test are presented in Table 4.

Table 4. Results of Tukey Post-Hoc Test on Student FMS Improvement

Tukey HSD

(I) Group	(J) Group	Mean Diff. (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Experiment 1	Experiment 2	6.014*	1.649	.001	2.09	9.94
	Control	7.317*	1.649	.000	3.39	11.24
Experiment 2	Experiment 1	-6.014*	1.649	.001	-9.94	-2.09
	Control	1.303	1.661	.713	-2.65	5.26
Control	Experiment 1	-7.317*	1.649	.000	-11.24	-3.39
	Experiment 2	-1.303	1.661	.713	-5.26	2.65

*. The mean difference is significant at the 0.05 level.

Based on the results of the Tukey post-hoc test in Table 4, a significant difference was found between Experimental Group 1 and Experimental Group 2 ($p < 0.001$). The mean difference between the two groups was 6.014, indicating that the improvement in students' fundamental movement skills (FMS) was higher in Experimental Group 1 than in Experimental Group 2. These findings indicate that although both experimental groups showed significant improvements—progressing from the "low" to the "average" category—greater gains were observed in the group taught by teachers with prior interdisciplinary PE experience.

Improvement of Student Numeracy Abilities

In addition to the improvement in FMS, the interdisciplinary PE learning also enhanced students' numeracy abilities. The results of the paired-sample t-test comparing pre-test and post-test numeracy scores are presented in Table 5.

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Table 5. Paired-Sample T-Test on Student Pre-Test and Post-Test Numeracy Abilities after Interdisciplinary PE Learning

		Paired Differences		Sig.
		Mean	Std. Deviation	(2 tailed)
Pair 1	Pre-test Numeracy (experiment 1) - Post-test Numeracy (exsperiment 1)	-23,823	8,006	,000
Pair 2	Pre-test Numeracy (experiment 2) - Post-test Numeracy (experiment 2)	-21,591	11,351	,000

Based on the results of the paired-sample t-test, the significance value for the improvement in students' numeracy abilities in both experimental groups was $p < 0.001$, indicating a statistically significant effect of the interdisciplinary PE intervention. The mean difference in Experimental Group 1 (taught by a teacher with prior interdisciplinary PE experience) between pre-test and post-test scores was −23.823, reflecting an average increase of 23.823 points. In Experimental Group 2 (taught by a teacher without prior interdisciplinary PE experience), the mean difference was −21.591, indicating an average increase of 21.591 points. These findings suggest that both implementations of interdisciplinary PE contributed to improvements in students' numeracy abilities, with slightly greater gains observed in Experimental Group 1. For the ANOVA test on the improvement of students' numeracy abilities after participating in interdisciplinary PE learning, the results are presented in Table 6.

Table 6. Results of The ANOVA Test on The Improvement of Student Numeracy Abilities

ANOVA					
Numerical Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3705.771	2	1852.885	22.695	.000
Within Groups	7919.229	97	81.642		
Total	11625.000	99			

Based on the comparison of numeracy gain scores across groups (Table 6), the results showed a statistically significant difference ($p < 0.001$), indicating that numeracy improvement varied among the groups. To further examine pairwise differences, a Tukey post-hoc test was conducted. The results are presented in Table 7.

Table 7. Results of The Tukey Post-Hoc Test on Student Numeracy Improvement

Tukey HSD						
					95% Confidence Interval	
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Experiment 1	Experiment 2	2.23262	2.20799	.001	-3.0229	7.4881
	Control	13.89929*	2.20799	.000	8.6438	19.1548
Experiment 2	Experiment 1	-2.23262	2.20799	.001	-7.4881	3.0229
	Control	11.66667*	2.22440	.000	6.3721	16.9612
Control	Experiment 1	-13.89929*	2.20799	.000	-19.1548	-8.6438
	Experiment 2	-11.66667*	2.22440	.000	-16.9612	-6.3721

*. The mean difference is significant at the 0.05 level.

Based on the results of the Tukey post-hoc test, a statistically significant difference in numeracy improvement was found between groups ($p < 0.001$), which indicates that the improvement in students' numeracy abilities after receiving interdisciplinary PE instruction delivered by teachers with prior experience in implementing this approach was better than that delivered by teachers without such experience. Specifically, a significant difference was

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observed between Experimental Group 1 and Experimental Group 2, with a mean difference of 2.23, indicating that the improvement in students' numeracy abilities was higher in Experimental Group 1. These findings suggest that although both experimental groups demonstrated significant improvements in numeracy abilities, greater gains were observed in the group taught by teachers with prior experience in implementing interdisciplinary PE.

DISCUSSION

Based on the findings presented above, interdisciplinary PE learning significantly improves students' fundamental movement skills (FMS). These findings are consistent with previous studies demonstrating the positive impact of interdisciplinary learning. For instance, an interdisciplinary approach, even when implemented independently, has been shown to enhance student learning outcomes (Kurniawan et al., 2019). In the context of physical education, interdisciplinary learning has also been associated with improvements in motor development. Previous research indicates that children's graphomotor development can be enhanced through interdisciplinary PE learning (Wawrzyniak et al., 2021). Norris et al. suggest that integrating physical activity learning with physical activity has a positive impact on physical activity and educational outcomes (Norris et al., 2020). Similarly, (Sit et al., 2019) integrated learning in physical education has been found to significantly improve motor skills and students' health In addition, interdisciplinary educational interventions implemented in elementary school settings have been shown to increase physical activity levels while simultaneously supporting the achievement of learning objectives (Oliveira et al., 2022).

The results of this study also show that interdisciplinary PE learning, which is an approach that integrates various aspects of PE such as FMS, health concepts, and the physical, emotional, and social development of students can have a significant impact on the development of students' FMS. This approach enables students to develop movement skills while simultaneously understanding the importance of physical activity for overall health and well-being. By providing varied and meaningful contexts, such as games, sports, and gymnastics activities, interdisciplinary learning facilitates the development of more adaptive and refined movement skills. In addition, this approach may enhance students' motivation and engagement in physical activity, as it connects learning with broader concepts such as health, fitness, and life skills, including those integrated with mathematics learning (Vazou et al., 2012).

Interdisciplinary PE learning provides opportunities for physical activity and social interaction, which, according to the cognitive development theories of Piaget and Vygotsky (Budiman et al., 2018), play an important role in the development of students' motor skills. Through this approach, students are engaged in rich movement experiences delivered through innovative and game-based activities that support the development of fundamental movement skills (FMS) while being integrated with mathematics learning. This approach also facilitates the transfer of motor skills across different activities, as students are exposed to varied movement contexts. Moreover, the design of interdisciplinary PE aligns well with the developmental characteristics of elementary school students, who tend to prefer play-based and socially interactive learning environments. At this stage, students are more inclined to engage in activities with their peers, and learning experiences that incorporate cooperative games, whether traditional or modified sports, can effectively support both skill development and social interaction. In addition, students at this level generally enjoy active movement and hands-on experiences. This is consistent with cognitive development theory, which suggests

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that elementary school students are in the concrete operational stage, where learning is most effective when it involves direct experience and observable activities. Therefore, the movement-rich and experiential nature of interdisciplinary PE learning provides an appropriate and supportive environment for optimizing students' motor skill development.

Field observations and teacher reports indicated consistent improvements across sessions, particularly in students' locomotor skills, such as running and jumping. Students who initially demonstrated lower proficiency in these skills showed notable progress following participation in the interdisciplinary PE program. For instance, during running activities, students initially exhibited less efficient foot placement upon ground contact; however, these movement patterns gradually improved over time. Similarly, in jumping tasks, suboptimal landing techniques observed during the early sessions were progressively refined, resulting in more controlled and effective movements. In terms of object control skills, several students initially demonstrated difficulties in catching and striking the ball. Pre-test observations revealed that some students were unable to catch the ball effectively. However, following the implementation of the interdisciplinary PE program, which incorporated game-based and movement-oriented activities, students' performance in these skills improved markedly, with fewer observable errors during subsequent sessions.

This study extends previous research on interdisciplinary physical education (PE), which has primarily focused on integrating PE with other subjects such as geography (Vlček et al., 2019) or examining its role in enhancing motor-related outcomes, including graphomotor development (Wawrzyniak et al., 2021) and overall motor skills and health (Sit et al., 2019).

In contrast, the present study specifically integrates PE with mathematics learning, thereby addressing a relatively underexplored area in interdisciplinary education. This approach is aligned with the theoretical perspective proposed by Estrada et al., (2019), which highlights the potential for integrating physical education with mathematics. The findings of this study demonstrate that interdisciplinary PE not only enhances students' fundamental movement skills but also contributes to improvements in their numeracy abilities. This provides empirical support for the effectiveness of integrating cognitive and physical domains within a single instructional framework.

Interdisciplinary PE enhances students' numeracy abilities through the integration of mathematical concepts into physical activity contexts, providing concrete learning experiences that support conceptual understanding. Within sports and game-based activities, students engage with mathematical concepts such as measurement, counting, and problem-solving in authentic and meaningful situations. At this developmental stage, children are in the concrete operational phase, in which they begin to apply logical reasoning with the support of tangible experiences. The use of the body as a learning medium in interdisciplinary PE strengthens concept retention by linking abstract mathematical ideas with physical actions. This process promotes a holistic learning experience, enabling students to simultaneously develop movement skills and numeracy competencies applicable to real-life situations. For example, in a soccer dribbling activity, students may be required to solve numeracy problems to guide their actions. A student might first determine the correct ball to use by solving a mathematical problem (e.g., calculating the remaining quantity after subtraction), and then decide the direction of movement based on another problem involving unit conversion. Such task design illustrates how mathematical reasoning can be embedded within physical activities, making learning more interactive and meaningful. This approach reflects the essence of interdisciplinary PE, particularly in elementary education, where

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developmental tasks emphasize the acquisition of practical and context-based knowledge (Iswanda & Furnamasari, 2023).

The progress in students' numeracy development was evident throughout the implementation of interdisciplinary PE. Teachers reported that during the initial sessions, many students experienced difficulty in solving numeracy problems and tended to rush through movement tasks, which often resulted in incorrect responses. However, as the sessions progressed, these difficulties gradually diminished, supported by teacher guidance and increased student engagement. By the later sessions, students were able to solve numeracy problems and perform the corresponding movement tasks more accurately and efficiently.

Based on these findings, integrating mathematics into physical education can create meaningful and contextually relevant learning experiences, thereby enhancing students' understanding and numeracy skills. This approach enables the delivery of more engaging and diverse learning content, which can increase students' motivation and active participation in the learning process (Cuervo, 2018; McPhail, 2018). Physical education holds unique potential in this regard, as it differs from conventional classroom-based learning by providing opportunities for active movement and experiential engagement. This environment allows students to express themselves more freely and reduces the monotony often associated with sedentary classroom activities, which may otherwise contribute to decreased learning motivation. However, if physical education is not designed innovatively and remains monotonous, this potential may not be fully realized and can instead lead to reduced student engagement.

To address this challenge, interdisciplinary PE learning has been proposed as an innovative instructional approach (Moss et al., 2019; Pountney & McPhail, 2019). This approach not only enhances student motivation but also encourages teachers to adopt and experiment with new pedagogical strategies (Kate et al., 2019). Consequently, interdisciplinary PE contributes to improvements in both students' fundamental movement skills (FMS) and numeracy abilities. Overall, interdisciplinary PE represents a shift in physical education toward a more holistic paradigm that emphasizes the development of lifelong skills, health, and fitness.

However, this study also identified teacher experience as an important supporting factor in the effectiveness of interdisciplinary physical education, particularly in improving students' fundamental movement skills (FMS) and numeracy abilities. Interdisciplinary learning requires substantial adjustments in both curriculum structure and instructional practice, including the transition from subject-based teaching to integrated learning approaches (Zach et al., 2017). As a result, less experienced teachers may encounter challenges in understanding and implementing integrated content effectively. In this context, teachers are required not only to master physical education content but also to develop sufficient understanding of the integrated subject, which in this case is mathematics. Mathematical concepts that are less familiar may need to be relearned and carefully adapted to fit movement-based activities. Furthermore, teachers must ensure that the learning objectives of both subjects are clearly understood and effectively achieved within a single instructional framework. Conversely, teachers with prior experience in implementing interdisciplinary PE are more likely to possess the pedagogical skills necessary to integrate numeracy concepts into physical activities. They tend to be more effective in designing engaging learning experiences that allow students to simultaneously develop motor and numeracy skills. In

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addition, experienced teachers are better able to anticipate potential barriers in the learning process and to develop appropriate instructional strategies to address them. This greater level of pedagogical competence enables experienced teachers to create more meaningful and enjoyable learning environments, while also helping students recognize the connection between motor skills and numeracy in a broader context. As a result, students' engagement and motivation to learn may be further enhanced.

Overall, teacher experience and expertise in implementing interdisciplinary PE play a crucial role in supporting the successful application of this approach. Effective integration between physical education and other subjects contributes to the creation of a learning environment that optimizes students' developmental outcomes. Consequently, teachers with prior experience in interdisciplinary PE tend to facilitate more effective learning processes, resulting in greater improvements compared to those with limited or no prior experience in this approach.

CONCLUSION

Based on the findings of this study, it can be concluded that interdisciplinary physical education (PE) programs have a positive and significant impact on elementary school students' fundamental movement skills (FMS) and numeracy abilities. Furthermore, the results indicate that teachers with prior experience in implementing interdisciplinary PE contribute to greater improvements, likely due to their ability to integrate subject content more effectively and address challenges during the instructional process. However, this study has several limitations, and further research is needed to explore the broader potential of interdisciplinary PE and to identify effective strategies for overcoming challenges in its implementation.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper is free of plagiarism.

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