ACPES Journal of Physical Education, Sport, and Health 5 (2) (2025)

ACPES Journal
of Physical Education, Sport, and Health

http://journal.unnes.ac.id/journals/ajpesh

Enhancing Pre-Service Physical Education Teachers' Knowledge through Curriculum-Aligned PETE Lessons in Cambodia

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DOI: https://doi.org/10.15294/ajpesh.v5i2.33969

Keywords

curriculum implementation, low-resource contexts, pedagogical content knowing (PCKg), physical education teacher education (PETE), specialized content knowledge

Abstract

Purpose: To examine the learnability of pre-service teachers' Specialized Content Knowledge (SCK) related to physical fitness within a brief, curriculum-aligned lesson in Cambodia's Physical Education Teacher Education (PETE) program. Method: Two 120-minute fitness lessons, aligned with the national secondary PE curriculum, were delivered at the National Institute of Physical Education and Sport (NIPES). Twenty-five candidates participated; analyses included 21 who completed all four administrations (Tests 1–4) of a seven-item Understanding level SCK knowledge test, which required selection of both the correct method and its rationale. In addition, all participants completed the Formative Lesson Assessment. Repeated-measures ANOVA examined baseline stability and intervention effects. Results: Knowledge scores showed no baseline change (Test 1–Test 2) significant pre- to post-lesson improvements, showing a large effect ($F(3, 60) = 9.754$, $p < .001$, partial $\eta^2 = .328$); Formative Lesson Assessment ratings were consistently high. Conclusion: In this intervention, a curriculum-aligned short lesson strengthened SCK for balance exercises and helped translate written curriculum aims into learned outcomes in a low-resource PETE setting, thereby providing practice-based evidence to inform teacher preparation in physical education. Given the intentionally brief, blueprint-sampled instrument and single-cohort design, inferences should be considered bounded to this cohort and instrument; broader generalization awaits further validation.

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e-ISSN 2797-0426

INTRODUCTION

Strengthening Physical Education Teacher Education (PETE) is a global priority, as intergovernmental processes—from MINEPS I (1976) to the Kazan Action Plan (2017) and subsequent monitoring—have repeatedly identified shortages of qualified Physical Education (PE) teachers and the need for evidence-informed teacher education (UNESCO, 1976, 1999, 2014, 2015, 2017; UNESCO & Loughborough University, 2024; Hardman, 2008).

In Fiji's secondary schools, studies report low subject status for PE and replacement or cancellation of PE lessons to accommodate other subjects; they also call for realigning PETE to curricular goals and note that the national Quality Physical Education (QPE) policy has yet to be implemented (Shirotriya et al., 2025). In sum, progress remains modest and shortages of qualified PE teachers persist; therefore, strengthening PETE through sustained, evidence-informed initiatives in higher education is a pressing priority, particularly in developing countries.

Amid these global trends, Cambodia's experience reflects both progress and ongoing challenges. Although the Khmer Rouge regime devastated its education sector in the 1970s, international support—particularly from the Japan International Cooperation Agency (JICA) and the Nonprofit Organization Hearts of Gold (HoG)—has supported the development and dissemination of physical education curricula and teaching manuals for primary and secondary schools (JICA, n.d.; HoG, 2016, 2021). Recent curriculum reforms, formally endorsed by the Ministry of Education, Youth and Sport (MoEYS) (Shibuya et al., 2024), reflect context-sensitive adaptations.

Even in higher education, the National Institute of Physical Education and Sport (NIPES), as the sole institution responsible for training secondary PE teachers in Cambodia, has undergone a series of reforms aimed at improving the quality of teaching in physical education. As described by Shibuya et al. (2024), recent reforms at NIPES include the introduction of curriculum frameworks aligned with modern pedagogical standards, faculty development programs, and enhanced teacher training processes. Naturally, as the system has only recently been established, addressing the lack of research focusing on pre-service PETE—an issue pointed out by Kon (2016), Yamahira et al. (2021), and Yamahira & Saito (2022)—can now be more realistically examined. NIPES is currently in an institutional transition from a two-year to a four-year bachelor's program. As such, investigating outcomes in the PETE program at NIPES at this stage holds value for understanding how teacher education unfolds in developing contexts.

While such reforms have strengthened the institutional foundation, "curriculum misalignment" remains a challenge in educational practice, referring to the gap between the intended curriculum and the learning outcomes actually achieved. Okade (2021) reports that official curricula are seldom implemented exactly as planned. Similarly, Hastie (2017) notes that in the field of physical education, the lack of empirical data on curriculum implementation, particularly in the United States, makes it difficult to assess whether curricular intentions are being realized in practice. To analyze such gaps, the curriculum framework developed by Glatthorn et al. (2019) is particularly useful, distinguishing among the recommended, intentional, learned and hidden curriculum. The recommended curriculum outlines broad policy recommendations and graduation requirements set by the education system. Intentional curriculum includes four interrelated components: the written curriculum, the supported curriculum, the taught curriculum, and the tested curriculum. If the intentional curriculum content is not being appropriately learned, it suggests the existence of a misalignment. Therefore, investigating how pre-service teachers at NIPES understand the written curriculum is a critical next step considering recent educational reforms.

To better understand the root of these misalignments, it is necessary to explore the types of knowledge PE teachers are expected to acquire through the curriculum and how this knowledge is assessed in practice. Recent scholarship on PETE indicates that programs often equate movement content knowledge with "physical performance," while knowledge for teaching—diagnosing common errors, designing progressive task sequences, and justifying rules and safety—receives comparatively little weight in program assessment (Backman et al., 2019). In response, this study focuses on teacher knowledge, with particular attention to Specialized Content Knowledge (SCK) within the PCKg framework. We adopt the PCKg lens (Cochran et al., 1993) as our analytic framework, while acknowledging Shulman (1987) as the foundational articulation of Pedagogical Content Knowledge (PCK). PCKg comprises four interrelated components—(1) Subject Matter Knowledge (SMK), (2) Pedagogical Knowledge, (3) Knowledge of Learners, and (4) Knowledge of Context (Cochran et al., 1993). Ball et al. (2008) distinguish common content knowledge (CCK)—rules, techniques, and tactics needed to do an activity—from SCK—knowledge for teaching that content.

Among these, regarding (1) Subject Matter Knowledge (SMK), Ward et al. (2015) operationalize SCK in physical education, clarifying that it encompasses the ability to identify common performance errors and design progressive task sequences that translate CCK into instructional components that can be effectively taught. When turning to the findings of prior research on these types of knowledge, A growing body of research indicates that many pre-service teachers enter PETE programs with limited CCK and particularly underdeveloped SCK (Tsuda et al., 2019). However, well-structured, practice-based interventions have shown that SCK can be improved efficiently within a single semester (Ward et al., 2018; Kim & Ko, 2017). Consistent with this, higher content knowledge is associated with richer enacted PCK behaviors (Kim, 2021). In this light, particularly in low-resource PETE contexts—such as those reported in Fiji—prioritizing SCK offers a high-leverage route to translate written curriculum aims into learned outcomes within limited contact time (Shirotriya et al., 2025).

However, in PETE programs in developing countries, there is a lack of empirical studies that examine the learnability of SCK within lessons that are explicitly aligned with the national curriculum. In this regard, the present study represents one of the initial attempts to empirically investigate the learnability of SCK through a curriculum-aligned lesson in a developing-country PETE context.

Therefore, the purpose of this study was to examine the learnability of SCK related to physical fitness within a curriculum-aligned lesson implemented in the PETE program at NIPES in Cambodia.

METHOD

Research Design

Following consultation with NIPES on scheduling, the study was conducted from February 14 to 23, 2023. During this period, two 120-minute lesson interventions were delivered on February 16 and February 23. To collect students' subjective evaluations of the lessons, a Formative Lesson Assessment (Takahashi et al., 1994, 2003) was administered. To assess students' knowledge, the same knowledge test was administered four times at different points during the intervention period. Test 1 was conducted on February 14, prior to any instruction. Test 2 was administered on February 16, immediately before the first lesson, followed by Test 3, which was given immediately after the same lesson. Test 4 was conducted on February 23, following the second lesson. Each knowledge test required approximately ten minutes to complete. Test 1 and Test 2 were conducted prior to the first lesson for two reasons: first, to establish baseline measures of student knowledge; and second, to control for any test-taking effect, ensuring that simply participating in a test would not independently influence knowledge levels.

Participants and Ethical Considerations

All 25 third-year students (23 men, 2 women) enrolled in the four-year program at the National Institute of Physical Education and Sport (NIPES), Phnom Penh, volunteered to participate. This study was approved by the Research Ethics Committee of Nippon Sport Science University (Approval No. 022-H163). All procedures conformed to the Declaration of Helsinki. A Khmer-language information sheet and consent form were provided; written informed consent was obtained from all 25 students before participation. Participation was voluntary, and students could withdraw at any time without penalty. Analyses used anonymized IDs only, and no individually identifying data are reported.

Lesson Planning

In practical contexts within developing countries, it is crucial to accurately understand the local background and needs to deliver effective, context-sensitive support. Particularly within the area of Sport for Development, active participation of local stakeholders in research and assessment is often emphasized to build mutual trust and ensure relevance (Spaaij et al., 2018). Moreover, Whitley et al. (2022) highlighted that PE programs must be carefully designed to fit local contexts, as a lack of contextual alignment can undermine educational outcomes. In line with these considerations, multiple preparatory meetings were conducted with NIPES staff and Teacher Training Center representatives. During these meetings, the research schedule and lesson plans were discussed with responsible teachers and administrators, and the intervention details were finalized following a review by the **President of NIPES**.

The lessons in this study were practical sessions conducted as part of the physical fitness class in the NIPES syllabus and were designed to align with Cambodia's national secondary school physical education curriculum, and to targeted the SMK-level content specified in the national curriculum

(MoEYS, 2016, 2018, 2019). ~~In this study, we targeted and assessed SCK for the safe performance of balance exercises.~~ Content was selected based on three criteria: alignment with curriculum guidelines, feasibility within the allotted time, and suitability for research data collection.

The content area of "Physical Fitness" was selected for the intervention. One of the reasons for this choice was the JICA support previously provided to NIPES. In this JICA initiative, "kumi-taiso" and "kumitate-taiso" (Japanese group gymnastics, or balance exercises) had been a core part of the teaching content used for various PE events such as sports festivals (Nippon Sport Science University, 2020). Furthermore, the teachers' manuals for Cambodia's high schools provide, in the physical fitness domain for Grades 10–12, sample lesson plans that treat balance exercises as sample lesson plans for balance exercises in the form of partner games (such as "back-to-back stand" and "push-hands-style exercises") and partner stretches (MoEYS, 2021a, 2021b, 2021c). Given their alignment with the teacher's manual and the MoEYS objective that "students learn the main knowledge of how to practice some skills with the help of friends" (MoEYS, 2021c, p. 22), balance exercises were selected as suitable content for this research.

The lessons were delivered by the first author in English, with assistance from an NIPES staff member to mitigate language barriers. Prior to the lessons, the author met with the NIPES staff member to review key instructional terms.

Data Collection

Formative Lesson Assessment

As a prerequisite for interpreting knowledge outcomes, it was necessary to confirm that the lessons had been appropriately received and implemented. Therefore, we also administered the Formative Lesson Assessment (Takahashi et al., 1994, 2003) to capture learners' perceptions of achievement, motivation & interest, learning processes, and cooperation. Although the Formative Lesson Assessment is based on students' subjective judgments, Takahashi et al. (2003) showed that these ratings are grounded in observable behavioral facts and can thus be regarded as well-founded and reliable. While this instrument is most commonly used with elementary and lower secondary students, prior studies have demonstrated that it is also applicable in high school and university contexts (Aoki et al., 2007; Matsumoto et al., 2014; Kawato et al., 2020).

Knowledge Tests

This study assessed participants' understanding of factual and procedural knowledge for the safe performance of balance exercises, positioned as SCK. The knowledge test was designed in accordance with Bloom's revised taxonomy (Anderson & Krathwohl, 2001) to target the Understanding level across factual and procedural knowledge.

The knowledge test was constructed with reference to the descriptions in the physical fitness sections of the teaching manuals (MoEYS, 2021a; 2021b; 2021c), aligned with Ball et al. (2008) and Ward et al. (2015) on diagnosing typical performance errors, anticipating risks, and justifying technique and safety principles. Accordingly, within the lesson context, respondents were required to select both the correct movement method and the most appropriate rationale. This response format was intended to elicit conditional understanding at Bloom's Understanding level of why a technique is appropriate rather than merely recalling what it looks like. Moreover, to appropriately and simply collect data in a developing-country context, and following Dick et al. (2004), we constructed seven multiple-choice items to minimize translation issues and accurately assess lesson outcomes, with four options for six items and three options for the seventh. Each item presented illustrated alternatives (one correct, three incorrect) and required respondents to select both the correct position/formation and its rationale, thereby indexing understanding rather than recognition. To minimize linguistic bias, materials underwent forward translation into Khmer and independent back translation (Wild et al., 2005), and any discrepancies were reconciled in consultation with NIPES staff.

In this developing-country, low-resource PETE setting with only one training institution and limited lesson time, we adopted a pragmatic, curriculum-aligned assessment. To strengthen causal interpretability under the constraint of a single cohort, two identical pre-instruction baselines (T1, T2) were administered under the same conditions, and the absence of a T1–T2 mean shift would indicate short-interval stability in this context. According to Tavakol and Dennick (2011), internal-consistency coefficients (e.g., Cronbach's alpha and Kuder–Richardson Formula 20/21) are single-administration indices of item homogeneity and do not assess stability over time. Moreover, because some examinees

may be uncertain and rely on guessing, which can reduce reliability (Paek, 2015), responses may vary across occasions. Therefore, we obtained short-interval stability evidence using duplicate pretests (T1, T2) rather than emphasizing internal-consistency indices. Content validity was established through alignment with MoEYS curriculum documents and review by a three-member expert panel (one Japanese university faculty member in PE pedagogy, one NIPES faculty member, and the first author).

As a prerequisite for interpreting knowledge outcomes, it was necessary to verify that the lessons were appropriately received and implemented. Therefore, we also administered the Formative Lesson Assessment (Takahashi et al., 1994; 2003) to capture learners' perceptions of achievement, motivation & interest, learning processes, and cooperation.

Data Analysis

In the analysis of both the Formative Lesson Assessment and the knowledge tests, 21 of the 25 participants who completed all four tests were included, while 4 were excluded due to incomplete test data.

Formative Lesson Assessment

For the Formative Lesson Assessment, we applied the diagnostic criteria of Takahashi et al. (2003) to interpret the Formative Lesson Assessment ratings for each lesson. Each item was scored as follows: 3 points for "Yes," 2 points for "Uncertain," and 1 point for "No." The average score across all respondents was calculated for each dimension, and we mapped that average onto a five-point scale (Takahashi et al., 2003). The five-point scale was interpreted based on diagnostic criteria that classify values from 1 to 5 according to the mean score for each dimension. For example, for the total score, a mean of 2.77 or higher corresponds to Level 5 and indicates that the lesson was evaluated as very good, whereas a mean of 2.33 or lower corresponds to Level 2, indicating that lesson improvement is required (Takahashi et al., 2003).

Knowledge Tests

For the knowledge test, analysis focused on changes in students' understanding of SCK for balance exercises as demonstrated in test performance. The average score of the 21 respondents was used to examine (1) changes in the total knowledge test score over time and (2) changes in scores on individual test items. Prior to conducting the repeated-measures ANOVA, we examined the score distributions at each measurement point for normality and potential outliers. Normality was evaluated using the Shapiro–Wilk test and inspection of normal Q–Q plots for each test score. Outliers were checked by inspecting stem-and-leaf displays and boxplots at each time point, confirming that no extreme values that markedly deviated from the overall score distributions were present. In addition, the sphericity assumption for the within-subjects factor was tested using Mauchly's test of sphericity. All statistical analyses were performed using IBM SPSS Statistics Version 27 with the significance level set to 5%. To examine the lesson intervention's effect, we performed a one-way repeated-measures ANOVA on Tests 1–4 scores. The comparison between Test 1 and Test 2 served as a baseline-equivalence check, as no intervention had occurred during this interval, and was treated as a design-based stability check. We calculated partial η^2 as an index of effect size, following Cohen's (1988) guidelines where values of .01–.06 indicate a small effect, .06–.14 a medium effect, and .14 or above a large effect.

RESULTS

Formative Lesson Assessment

The results of the Formative Lesson Assessment are presented in Table 1. On the five-point diagnostic scale, "Achievement," "Learning Process," "Cooperation," and "Total" were all rated 5 for both lessons, whereas "Motivation & Interest" was rated 4 for both lessons. These findings indicate that the lessons implemented in this study were generally rated highly by participants and were appropriately implemented.

Table 1. Formative Lesson Assessment Scores (n = 21)

Indicator	Lesson 1		Lesson 2	
	(*M* ± *SD*)	Criterion	(*M* ± *SD*)	Criterion
Achievement	3.00 ± 0.00	5	3.00 ± 0.00	5
Motivation & Interest	2.71 ± 0.72	4	2.90 ± 0.44	4
Learning Process	2.76 ± 0.62	5	2.90 ± 0.44	5
Cooperation	3.00 ± 0.00	5	3.00 ± 0.00	5
Total	2.87 ± 0.22	5	2.95 ± 0.15	5

Changes in Knowledge Test Scores

Tests of normality indicated that none of the Shapiro–Wilk tests at any measurement point were significant at the 5% level ($p > .05$), suggesting that the score distributions did not substantially deviate from normality. Inspection of stem-and-leaf displays and boxplots further indicated that there were no extreme outliers that markedly deviated from the remaining values. A one-way repeated-measures ANOVA on total knowledge test scores revealed a significant main effect of time, $F(3, 60) = 9.754$, $p < .001$ (Table 2). Mauchly's test of sphericity indicated that the sphericity assumption was not violated, $W = .832$, $\chi^2(5) = 3.451$, $p = .631$, and therefore degrees of freedom are reported under the assumption of sphericity. Bonferroni-adjusted pairwise comparisons showed no significant difference between the two pre-intervention tests (Test 1 vs. Test 2; $p > .05$), confirming that the pre-intervention baseline was stable (Table 2). Scores on Test 3 and Test 4 were significantly higher than those on Test 1 and Test 2 ($p < .01$). Moreover, the partial η^2 for the main effect was .328, indicating a large effect size. Thus, scores did not change across the two pre-intervention baseline measurements, but increased significantly following the first lesson and remained at a similar level after the second lesson.

Table 2. Changes in Knowledge Test Scores (n = 21)

Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	11.90	3.58	9.754	< .001*	Test 1 < Test 3, Test 4	.328
Test 2	21	13.05	3.19			Test 2 < Test 3, Test 4	
Test 3	21	15.00	3.82			Test 1, Test 2 < Test 3	
Test 4	21	15.67	3.22			Test 1, Test 2 < Test 4	

effect size: large

Note. Maximum possible score = 27. Multiple comparisons are Bonferroni-adjusted. * $p < .05$.

Changes in Knowledge Test Scores by Question

A one-way repeated-measures ANOVA on the scores for each question from Tests 1–4 showed a significant main effect for Question 3 and Question 7 ($F(3, 60) = 3.818$, $p = .014$; $F(3, 60) = 14.528$, $p < .001$) (Table 3). Bonferroni post hoc tests indicated that there were no significant differences between Test 1 and Test 2 scores for all questions ($p > .05$). In contrast, for Question 3 and Question 7, scores on Test 3 were significantly higher than those on Test 1 and Test 2 ($p < .05$). The partial η^2 values were .160 for Question 3 and .421 for Question 7, both indicating large effect sizes. For the remaining questions, effect sizes were medium for Questions 1, 2, 4, and 5 and small for Question 6, and consequently these differences did not reach statistical significance. Taken together, these findings indicate that significant gains at the item level were concentrated in Questions 3 and 7, whereas improvements on the remaining items were smaller and did not reach statistical significance.

Discussion

Formative Lesson Assessment results serve as supplemental indicators of lesson satisfaction, suggesting that the lessons were well received and properly implemented. Based on the lesson results on SCK, baseline scores between Test 1 and Test 2 did not differ, indicating that understanding of knowledge had not improved without a deliberate learning opportunity. After the first lesson, mean scores rose significantly from Test 2 to Test 3 ($p < .05$) and remained stable one week later in Test 4.

Table 3. Changes in Knowledge Test Scores by Question (n = 21)

Question 1		Maximum: 4					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	2.1	0.8	1.000	.372		.048
Test 2	21	2.0	0.5				
Test 3	21	2.0	0.9				
Test 4	21	2.2	0.7				
							effect size: medium
Question 2		Maximum: 4					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	1.52	0.93	1.571	.206		.060
Test 2	21	1.71	1.19				
Test 3	21	2.19	1.29				
Test 4	21	1.81	0.75				
							effect size: medium
Question 3		Maximum: 4					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	2.3	1.1	3.818	.014*		.160
Test 2	21	2.1	0.9			Test 2 < Test 4	
Test 3	21	2.6	0.7				
Test 4	21	2.9	0.6			Test 2 < Test 4	
							effect size: large
Question 4		Maximum: 4					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	1.7	1.0	2.400	.077		.102
Test 2	21	1.9	1.2				
Test 3	21	2.2	1.0				
Test 4	21	2.3	0.9				
							effect size: medium
Question 5		Maximum: 4					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	1.7	1.0	1.988	.125		.090
Test 2	21	2.0	1.0				
Test 3	21	2.3	0.8				
Test 4	21	1.9	0.9				
							effect size: medium
Question 6		Maximum: 4					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	1.7	1.4	2.250	.092	□	.101
Test 2	21	2.3	1.4				
Test 3	21	2.4	1.5				
Test 4	21	2.5	1.3			□	
							effect size: medium
Question 7		Maximum: 3					
Test times	*n*	*M*	*SD*	*F*	*p*	Multiple comparison	Effect size (partial $\eta^{2)}$
Test 1	21	1.0	0.9	14.528	< .001*	Test 1 < Test 4	.421
Test 2	21	1.0	0.7			Test 2 < Test 4	
Test 3	21	1.3	0.9			Test 3 < Test 4	
Test 4	21	2.0	0.8			Test 1, Test 2, Test 3 < Test 4	
							effect size: large

Note. Maximum possible score = 27. Multiple comparisons are Bonferroni-adjusted. * p < .05.

The large effect size (partial $\eta^2 = .328$) suggests that a single 120-minute intervention can substantially enhance students' understanding.

When interpreted in light of the theoretical frameworks (Cochran et al., 1993; Glatthorn et al., 2019; Anderson & Krathwohl, 2001), the improvement in test scores suggests that SCK was understood during the lessons. Interpreted through the lenses of PCKg (Cochran et al., 1993) and Bloom's revised taxonomy (Anderson & Krathwohl, 2001), the findings demonstrate that factual and procedural knowledge within the Understanding level is learnable within a short intervention. Moreover, the significant SCK gains observed in our Cambodian sample replicate those reported in practice-based PETE modules from the United States and Turkey (Kim & Ko, 2017). Kim (2021) specifically found that pre-service teachers with higher levels of content knowledge—including the specialized component of SCK—demonstrated more mature forms of enacted PCK. This linkage reinforces the case for strengthening SCK in teacher-education curricula and is directly relevant to the Cambodian PETE context examined in this study.

The variation observed in students' knowledge improvements indicates that the learnability of SCK differs across specific questions and may serve as a starting point for exploring how instructional design can better support student understanding in response to varying levels of cognitive demand. More specifically, when the knowledge test in this study was examined item by item, variation in the magnitude of score gains was observed, indicating that the learnability of SCK differed across items. In particular, large effect sizes were observed for Questions 3 and 7, whereas effect sizes for Questions 1, 2, 4, and 5 were in the medium range and that for Question 6 was small. This pattern suggests that, even within SCK for balance exercises, some types of knowledge are more amenable than others to improvement through a brief intervention, depending on the nature of the content. On the basis of these interpretations, the following sections discuss implications for lesson design and curriculum improvement.

Building on these interpretations, we first consider implications for lesson design and PETE practice. From an instructional design and PETE practice perspective, the findings provide empirical support for Ward and Ayvazo's (2016) argument that instructional approaches must be deliberately adjusted to accommodate differences in learnability across content knowledge domains. Building on this line of reasoning, identifying such variation may inform future efforts to develop knowledge-specific strategies for promoting the acquisition of SCK. From a curriculum-implementation perspective, variation in item-level gains points to specific SCK elements that were harder for candidates to learn. Mapping these lower-gain elements back onto lesson tasks provides concrete targets for revising exemplars, practice progressions, and feedback cues in the next iteration. This finding suggests that demonstrating measurable gains through explicit SCK instruction combined with written assessment within short lesson windows could inform PETE realignment in resource-limited contexts such as Fiji (Shirotriya et al., 2025).

Next, from a curriculum-implementation and quality-assurance perspective, as ~~As~~ Glatthorn et al. (2019) emphasize, scrutinizing how written curriculum intentions manifest in actual learning outcomes is essential for quality assurance. The instructional objective set by the MoEYS (2021c, p. 22)—"students learn the main knowledge of how to practice some skills with the help of friends"—was examined through knowledge test results. Significant gains at the Understanding level suggest that these curriculum elements were appropriately enacted in the lesson, while smaller gains highlight areas for future revision. These findings offer a concrete starting point for ongoing efforts to enhance curriculum quality.

In addition, within the context of international policy discussions, The significant improvements in the Understanding level in our Cambodian sample are consistent with the gains reported in practice-based PETE interventions conducted in well-resourced U.S. programs (Ward et al., 2018). This study constitutes one example of a response to UNESCO's long-standing call (UNESCO, 2014, 2017, 2024) for empirical strategies that bolster teacher knowledge in developing countries.

Limitations

It is important to note several limitations in this study. Although this research focused on SCK, it addressed a single content area (physical fitness) and assessed knowledge at the Understanding level of the revised Bloom's taxonomy, specifically within the procedural and factual knowledge dimensions. To obtain a more comprehensive picture of curriculum implementation effects in PETE, future research should explore other levels of the Cognitive Process Dimension and types within the Know-

ledge Dimension, such as Conceptual and Metacognitive knowledge. Moreover, the measurements in this study were limited to short-term change; it will be important to examine how knowledge develops over longer intervention periods. Future work should extend to other content strands and cognitive processes, and triangulate knowledge tests with performance-based assessments to strengthen inferences about SCK.

Additionally, this single-institution study used a small analyzed sample (n = 21) and lacked a control group, limiting causal inference and generalizability. The instrument was brief and blueprint-sampled, targeted Understanding level SCK in a single content strand, and we did not estimate internal consistency or conduct item-level diagnostics; this is consistent with the point that internal-consistency indices address content sampling within a single administration rather than stability over time (Tavakol & Dennick, 2011). Uncertainty and guessing can undermine stability over time and reduce reliability (Paek, 2015), so although duplicate pretests (T1, T2) were used to check baseline stability, they provide mean-level evidence only and within-person agreement remains unquantified. In this respect, the present study provides only preliminary evidence regarding the temporal stability and within-person reliability of the SCK test.

Taken together, these design-bounded choices clarify the scope of inference and suggest several priorities for future research: quantifying within-person agreement (for example, by estimating test–retest reliability using intraclass correlation coefficients [ICC]); developing homogeneous subscales that permit appropriate estimation of internal consistency; and, where feasible, conducting item-level diagnostic analyses. In addition, replication studies with larger samples and quasi-experimental or comparative designs including control conditions are needed to test and extend the curriculum-implementation effects observed in this study.

CONCLUSION

Drawing on Glatthorn's curriculum framework, this study designed and implemented a curriculum-aligned physical fitness lesson intervention within a pre-service physical education teacher education program in Cambodia, with the aim of examining the learnability of Specialized Content Knowledge (SCK) in secondary physical education. Formative Lesson Assessment results indicated that students were satisfied with the instructional approach. The knowledge test showed significant gains in total scores: no change was observed across the two pre-intervention baseline tests (Tests 1 and 2), whereas scores increased significantly after the first lesson (Test 3) and remained at a similar level after the second lesson (Test 4). Taken together, these findings suggest that, although SCK is context dependent, it can be sufficiently learned over a short period when instruction is intentionally designed and aligned with the national curriculum.

In this study, we also observed variation in knowledge test scores assessing SCK, suggesting that students' understanding varied depending on the difficulty of each knowledge test item and the specific context in which the knowledge was assessed. Identifying the factors contributing to lower scores on particular knowledge test items is therefore a critical task for future work aimed at strengthening the individual components that constitute SCK.

By starting from national curriculum intentions, designing lessons accordingly, visualizing learning outcomes through an SCK test, and feeding the results back into curriculum discussion, this study illustrated a coherent process for linking curriculum implementation with evidence-based reflection. In this sense, it offers an empirical model for testing the validity of PETE improvement efforts in resource-constrained settings and provides a basis for future work seeking to enhance PETE through curriculum-aligned, outcome-focused interventions.

Conflict of Interest

The authors declare no conflict of interest.

Funding

No specific funding was received for this work.

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