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PEDAGOGY

Effects of a Training Program on Pre-Service Physical Education Teachers' Skill Analysis Ability

Shern Meng Tan

Abstract

Although skill analysis ability is crucial for physical education (PE) teachers, it is underemphasized by physical education teacher education (PETE) programs. This study aims to examine the effects of a training program on pre-service PE teachers' skill analysis ability. Utilizing a quasi-experimental research design, 36 pre-service PE teachers (experimental group) participated in a skill analysis training program for eight motor skills while no training was provided for 37 Sport Science and Management (SSM) undergraduates (control group). Based on a four-step model (Knudson, 2013), the skill analysis training program introduced participants to eight motor skills and their critical features. Participants also watched videos of correct skill performances and practiced analyzing incorrect skill performances using the same videos. For both groups, the skill analysis ability of the eight motor skills was measured before (pre-test), immediately after (post-test), and six weeks after (retention test) the training program. For the experimental group, a large and statistically significant increase in skill analysis ability was observed between the pre- and post-tests, while a statistically insignificant decrease in skill analysis ability was observed between the post- and retention tests. For the control group, a small but statistically significant increase in skill analysis ability was observed between

Shern Meng Tan, Lecturer, National Institute of Education, Nanyang Technological University. Please send author correspondence to shernmeng.tan@nie.edu.sg

the pre- and post-tests, and a statistically insignificant decrease in skill analysis ability was observed between the post- and retention tests. The results indicated that pre-service PE teachers were unable to analyze motor skills prior to the PETE program, and the training program effectively improved their skill analysis ability, which was retained six weeks later. More importantly, the pre-service PE teachers attained the established competency level for eight motor skills after the skill analysis training program. Thus, the study supports the inclusion of skill analysis training in PETE programs.

Introduction

Skill analysis is an important ability that PE teachers must possess, referring to the systematic observation and introspective judgment of the quality of human movement to provide the most appropriate intervention to improve performance (Knudson, 2013). Experienced PE teachers frequently use their skill analysis ability in their classes to provide feedback, manage the classroom, and inform teaching practice (Siedentop & Tannehill, 2000). Likewise, Metzler (2011) and Rink (2014) considered skill analysis to be an essential skill for PE teachers, enabling them to provide students with feedback, assess their performance, or make decisions about what to do next. Most recently, Ward et al. (2021) discussed the importance of PE teachers' skill analysis ability, its place in PE teachers' content knowledge, and how PETE programs can develop PE teachers' skill analysis ability. It was suggested that PE teachers' skill analysis abilities can be enhanced by using criteria checklists and peer teaching strategies during courses, incorporating technology such as video software, to provide PE teachers with more precise and detailed skill analysis. Opportunities to analyze students' skill performances can also be found during practicum and formative assessment. Most importantly, Overdorf and Coker (2013) argued that PETE programs have "traditionally relied on a fragmented single sub-disciplinary approach" (p. 198), short-changing PE teachers in terms of their skill analysis ability. They proposed that PETE programs should adopt an integrated four-step model (Knudson, 2013) to develop the skill analysis ability of PE teachers.

A Four-Task Model for Skill Analysis Training

Knudson and Morrison (1996) and Knudson (2000) proposed a skill analysis model that integrated many subdisciplines of PE (e.g., biomechanics, motor learning, and pedagogy), and comprised four tasks: preparation, observation, evaluation/diagnosis, and remediation. PE teachers must first prepare to analyze the skill by identifying its critical features from research, professional literature, and experience. Next, PE teachers should observe multiple attempts of the skill from positions where they can see most or all of the critical features. After observing, PE teachers evaluate and diagnose skill performance by determining whether the critical features were performed correctly, incorrectly, or not at all. Lastly, PE teachers remediate skill performance by providing feedback, modifying practice, or praising the performer if the skill was performed correctly. Knudson (2013) emphasized that skill analysis is a key teaching skill that is interdisciplinary and should be systematically addressed by the curriculum in teacher preparation and other kinesiology programs, rather than residing solely in a specific course, such as Biomechanics.

Studies on Skill Analysis Training

The training of PE teachers' skill analysis ability remains understudied, with less than 30 studies conducted in the past five decades. In terms of skill analysis training, limited studies have generally found that videotape-based instruction, complemented with skill checklists, is effective for pre-service PE teachers (e.g., Cloes et al., 1995; Gangstead & Beveridge, 1984). Skill analysis training without instructors was found to be less effective e.g., self-directed training programs (Walkley & Kelly, 1989), multimedia interactive laserdisc computer-driven training programs (Williams & Tannehill, 1999), computer-based distance learning (McKethan et al., 2003), and peer-teaching among undergraduates (Pulling & Allen, 2014). Also, studies indicated that skill analysis training is specific and not transferable (Gangstead & Beveridge, 1984; Wilkinson, 1996).

In terms of the skills analyzed, the overarm throw is the most analyzed skill (e.g., Haynes & Miller, 2015), and studies have also focused on specific games/sports, e.g., Volleyball (Bayless, 1981; Cloes et al., 1995; Moon & Park, 2023; Nielsen & Beauchamp, 1991; Soyturk, 2019; Wilkinson, 1991, 1992). Previous studies have trained

participants to analyze various skills, with nine studies including only one skill (Armstrong & Hoffman, 1979; Eckrich et al., 1994; Imwold & Hoffman, 1983; Kelly & Bishop, 2013; Kelly & Moran, 2010; Kelly et al., 2012; McKethan et al., 2003; Walkwitz & Lee, 1992; Wilson et al., 2021) and seven studies including three skills (Bayless, 1981; Morrison & Harrison, 1985; Morrison & Reeve, 1988, 1992; Morrison et al., 1992; Wilkinson, 1991, 1992). Only one study included nine skills (e.g., Williams & Tannehill, 1999). The training duration of skill analysis ability depended on the number of skills covered and varied between studies, ranging from 40 minutes (Morrison & Reeve, 1986) to twelve weeks (Nielsen & Beauchamp, 1991). The number of skills included in each study is more often an afterthought. As highlighted by Haynes and Miller (2015), studies were more concerned with reporting the novelty of their skill analysis training programs rather than the number of motor skills that PE teachers can analyze after training.

Only five studies have examined the retention of the participants' skill analysis ability (e.g., McKethan et al., 2003). It was found that skill analysis ability has been retained for a week (Kelly et al., 2012), two weeks (Eckrich et al., 1994), and two months (Morrison & Harrison, 1985) but not retained one year later (Wilkinson, 1992). More recently, Kelly and his colleagues examined the effectiveness of a web-based interactive video assessment program in training PE teachers to analyze skills, and both pre-service and in-service PE teachers' analysis ability improved for the skills of kicking and underhand roll (Kelly & Bishop, 2013; Kelly & Moran, 2010; Kelly et al., 2012; Wilson et al., 2021). Most importantly, few of the studies by Kelly and his colleagues have enabled their participants to attain the established level of 80% for skill analysis to be considered competent (Kelly & Moran, 2010; Walkley & Kelly, 1989; Williams & Tannehill, 1999).

In summary, the training of PE teachers' skill analysis ability remains understudied in the past decades. While some studies indicated that skill analysis training programs are best supported by the presence of instructors and the use of skill checklists, few studies have enabled PE teachers to analyze a variety of motor skills competently.

Skill Analysis Training in Singapore's PETE programs

The PETE programs in Singapore underemphasize skill analysis training (National Institute of Education, 2020a, 2020b, 2020c). Although pre-service PE teachers read kinesiology or biomechanics courses, past studies indicated that such courses offer few opportunities to acquire skill analysis ability (Abendroth-Smith et al., 1996; Morrison & Harrison, 1997; Wilkinson, 2000). Likewise, the plethora of physical activity courses, (e.g., Badminton, Basketball, Dance, Floorball, Curriculum Gymnastics, Soccer, Softball, Track & Field, and Volleyball), attended by pre-service PE teachers, emphasized learning the game/sport skills but do not equip them with skill analysis ability.

Situated within Singapore's PETE programs, this study is one of the first to examine the effects of a training program on pre-service PE teachers' skill analysis ability. The significance of this study is (1) the contribution to the limited literature on skill analysis training, and (2) the potential of inclusion or incorporation of skill analysis training by the PETE programs. For this study, two research questions were addressed: (1) Did pre-service PE teachers' skill analysis ability improve after the training program? (2) Did pre-service PE teachers retain their skill analysis ability six weeks after the training program? Based on the literature reviewed, it is hypothesized that the pre-service PE teachers' skill analysis ability will improve after the training program and will be retained six weeks after the training program.

Method

Participants

Thirty-six pre-service PE teachers (17 males, 19 females, mean age = 27.42 ± 4.18 years) and 37 SSM undergraduates (21 males, 16 females, mean age = 22.86 ± 1.51 years) participated in the study. Approval from the university's institutional review board (IRB-2020-06-031) and informed consent from the participants were obtained before the start of the study.

Instrument

To measure skill analysis ability, participants watched eight skill performances and rated whether their critical features were present and performed correctly. The eight skills coincided with those taught in Singapore schools (Ministry of Education, 2016), and are often assessed to establish motor proficiency among children (Ulrich, 2000, 2013), i.e., catch, dribble with hand, kick, roll (underhand), strike with bat, strike with racket, throw (overhand), and throw (underhand). The number of critical features ranged from five to eleven, and participants rated their skill performances on criteria sheets. Each criteria sheet contains illustrations of the skills and their critical features, obtained from Colvin et al.'s (2016) Teaching Fundamental Motor Skills, a course text often used by PETE programs and considered a valid and accurate source (Knudson, 2013). Participants watched the skill performances on videos. The skills were performed by school-age children and videotaped from the best vantage point (Knudson, 2013) (i.e., appropriately distanced, situated in front of a uniform background, capturing the performer's dominant side, and at a right angle to the plane of motion). In each video, the skill performance contains several errors, i.e., critical features are missing or performed incorrectly. Participants are afforded the use of video functions, such as pause, freeze frame, and slow motion, when watching the skill performance videos. Participants took no more than 30 minutes to watch and rate the eight skill performances on videos.

Participants' skill analysis ability is reported as a percentage and determined by comparing their responses against a reference developed by three subject matter experts: two university faculty members specializing in PE and a PE curriculum specialist from the education ministry. To control for testing threats (Thomas et al., 2011), separate sets of fundamental motor skill performance videos were used, and separate references were developed for the pre-, post-, and retention tests. For the pre-, post-, and retention tests' references, intraclass correlation coefficient estimates and their 95% confident intervals were calculated using SPSS statistical package version 28 (SPSS Inc, Chicago, IL) based on a mean-rating ($k = 3$), absolute-agreement, 2-way mixed effects model (Koo & Li, 2016). Intraclass correlation coefficient values were 0.943, 0.944, and 0.935 for the pre-, post-,

and retention tests, respectively, indicating excellent reliability for all three tests.

Skill Analysis Training Program

Overdorf and Coker (2013) proposed that PETE programs should adopt an integrated four-step model (Knudson, 2013) to develop the skill analysis ability of PE teachers. The skill analysis training program comprises four learning activities and is based on Knudson's (2013) four-task model, which includes preparation, observation, evaluation, diagnosis, and intervention. The first and second learning activities are based on the first task of preparation. The third and fourth learning activities are based on the second task, observation, and the third task, evaluation and diagnosis. The skill analysis training program does not address the fourth task of intervention, as the participants are not required to propose interventions to correct the errors observed in the videos.

For the first learning activity, participants were provided with criteria sheets containing illustrations and critical features of the eight identified skills. The instructor then introduced the sequence and critical features of these skills. The eight identified skills coincided with those taught in Singapore schools (Ministry of Education, 2016), and are often assessed to establish motor proficiency among children (Ulrich, 2000, 2013), i.e., catch, dribble with hand, kick, roll (underhand), strike with bat, strike with racket, throw (overhand), and throw (underhand). The number of critical features ranged from five to eleven for each skill. The illustrations and critical features of the skills are obtained from Colvin, Markos, and Walker's (2016) Teaching Fundamental Motor Skills. The course text is often used by PETE programs and is considered a valid and accurate source (Knudson, 2013).

The second learning activity was instructor-led, and participants were shown correct skill performance videos, i.e., all the skill's critical features are present and performed correctly. The correct skill performance videos are first shown in real-time and without the instructor's comments to give participants an overall impression. The correct skill performance videos are subsequently shown in slow motion or freeze frame, and the instructor highlights the critical features whenever they occur. Also, the correct skill performance

videos were made available to the participants as a reference for the subsequent learning activities.

The third learning activity was instructor-led, and participants were shown incorrect skill performance videos (i.e., some or all of the skill's critical features were absent or performed incorrectly). The incorrect skill performance videos are first shown in real-time, without the instructor's comments, to give participants an overall impression. The incorrect skill performance videos are subsequently shown in slow-motion or freeze frame, and the erroneous or missing critical features are highlighted whenever they occur. Five incorrect skill performance videos, performed by different school-age children and videotaped from the best vantage point (i.e., appropriately distanced, situated in front of a uniform background, capturing the performer's dominant side, and the right angle to the plane of motion) (Knudson, 2013), were shown for each skill that participants are required to analyze.

For the fourth learning activity, participants were tasked to rate incorrect skill performances on their own time before comparing their ratings with the instructors. Four incorrect skill performance videos, performed by different school-age children and videotaped from the best vantage point, i.e., appropriately distanced, situated in front of a uniform background, capturing the performer's dominant side, and the right angle to the plane of motion (Knudson, 2013), were provided for each skill that participants are required to analyze. Participants are afforded the use of slow-motion and/or freeze-frame functions when rating the incorrect skill performance videos.

The skill analysis training program followed a typical university course schedule, consisting of three-hour sessions per week over a three-week period. The first and second activities are scheduled for the first session, and the third and fourth activities are scheduled for the second and third sessions, respectively.

Procedure

A quasi-experimental research design was adopted for this study (Thomas et al., 2011), where pre-service PE teachers were recruited into the experimental group, and SSM undergraduates were recruited into the control group at the beginning of their respective programs. Pre-service PE teachers and SSM undergraduates were considered similar and have been recruited in previous studies (Eckrich et al.,

1994; Morrison & Reeve, 1988). Data collection and the skill analysis training program were scheduled during the academic semester to facilitate participation. During the first week of the academic semester, all the participants completed the pre-test. The skill analysis training program was conducted during the second, third, and fourth weeks of the academic semester for the experimental group, with each participant undergoing a three-hour session each week. The control group received neither information nor training regarding skill analysis from the investigator, except on the three occasions when the measures were administered. All the participants completed the post- and retention tests during the fourth and 13th weeks of the academic semester, respectively.

Data Analysis

Participants' responses to the criteria sheets were checked for completeness and compared to the respective references (i.e., the pre-test, post-test, and retention test, to generate percentages for each test). The data are then entered into a computer for analysis using SPSS statistical package version 28 (SPSS Inc., Chicago, IL). Due to the small sample sizes, presence of outliers, and violations of the assumptions of normality (Pallant, 2013), non-parametric statistics were used to compare the pre-test, post-test, and retention test scores between and within the experimental and control groups.

Results

Descriptive statistics of the pre-, post-, and retention test scores for the experimental and control groups were generated and presented in Table 1. Mann-Whitney U Tests revealed no significant differences between the pre-test scores of the experimental (Md = 57.35%, n = 36) and control (Md = 58.82%, n = 37) groups, U = 679, z = -.144, p = .886, r = .02, significant differences between the post-test scores of the experimental (Md = 88.97%, n = 36) and control (Md = 64.71%, n = 37) groups, U = 0, z = -7.361, p < .001, r = .86, and significant differences between the retention scores of the experimental (Md = 84.56%, n = 36) and control (Md = 61.76%, n = 37) groups, U = 0, z = -7.356, p < .001, r = .86.

A Friedman test was conducted to determine if there were differences in skill analysis ability between the experimental group during the skill analysis training program and six weeks after (see Table 2).

Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons. Skill analysis ability was statistically significantly different at the different time points, $\chi^2(2) = 57.52$, $p < .001$. Post hoc analyses revealed statistically significant differences between pre-test (Md = 57.35%) and post-test (Md = 88.97%; $p < .001$), pre-test (Md = 57.35%) and retention test (Md = 84.56%; $p < .001$), but not post-test (Md = 88.97%) and retention test (Md = 84.56%; $p = .297$).

A Friedman test was run to determine if there were differences in skill analysis ability during the skill analysis training program and six weeks after for the control group (see Table 2). Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons. Skill analysis ability was statistically significantly different at the different time points, $\chi^2(2) = 7.56$, $p = .023$. Post hoc analyses revealed a statistically significant difference between pre-test (Md = 58.82%) and post-test (Md = 64.71%; $p = .023$), but not pre-test (Md = 58.82%) and retention test (Md = 61.76%; $p = .544$), and post-test (Md = 64.71%) and retention test (Md = 61.76%; $p = .544$).

Discussion

Improvement of Skill Analysis Ability

This study aimed to examine the effects of a training program on pre-service PE teachers' skill analysis ability. The first research question was whether pre-service PE teachers' skill analysis ability improved after the training program, and it was hypothesized that this ability would improve after the training program. Corroborating with previous studies (Kelly & Bishop, 2013; Kelly & Moran, 2010; Kelly et al., 2012; Walkley & Kelly, 1989; Wilson et al., 2021), it was found that the pre-service PE teachers' skill analysis ability improved after the training program. Additionally, studies have suggested that skill analysis training offers wider benefits, allowing PE teachers to plan and enact more effective lessons and provide more targeted feedback to their students. For example, Walkwitz and Lee (1992) found that teachers who are skill analysis trained had more knowledge of the skill, were more concerned with the student's skill performances, and structured their lesson activities so that the students' practices were higher in quality. In addition, apart from being able to better analyze skills, skill analysis training not only improved participants'

Table 1

Descriptive Statistics and Mann-Whitney U Tests for Pre-, Post-, and Retention Tests between Experimental and Control Groups

Test	Exp		Con		U	z	p	r
	n	Md	n	Md				
Pre	36	57.35%	37	58.82%	679.00	.144	.886	.02
Post	36	88.97%	37	64.71%	0.00	-7.361	<.001	.86
Ret	36	84.56%	37	61.76%	0.00	-7.356	<.001	.86

Note: Exp – Experimental; Con – Control; Ret – Retention

Table 2

Friedman Tests for Pre-, Post-, and Retention Tests Within Experimental and Control Groups

Group	Test	N	Md	Mean rank	Chi-square	df	p
Exp	Pre	36	57.35%	1.00	57.52	2	<.001
	Post	36	88.97%	2.69			
	Ret	36	84.56%	2.31			
Con	Pre	37	58.82%	1.69	7.56	2	.023
	Post	37	64.71%	2.31			
	Ret	37	61.76%	2.00			

Note: Exp – Experimental; Con – Control; Ret – Retention

knowledge of the skill's critical features but also the amount of feedback given to students (Cloes et al., 1995). Results from this study reinforced the need for skill analysis training among pre-service PE teachers. Apart from enabling the pre-service PE teachers to analyze motor skills, they are also more likely to plan better lesson activities and provide more feedback for their students.

This study's findings are consistent with prior research indicating that pre-service PE teachers are often unable to analyze skills without formal training (Kelly & Bishop, 2013; Kelly & Moran, 2010; Kelly et al., 2012). There were no significant differences in the pre-test scores between the experimental and control groups, indicating that both groups lacked skill analysis ability at the beginning of their respective programs. With pre-test scores of 57.35% and 58.82% for the experimental and control groups, respectively, they do not enter their respective programs with the established level of 80% for skill analysis to be considered competent (Kelly & Moran, 2010; Walkley

& Kelly, 1989; Williams & Tannehill, 1999). While skill analysis ability is crucial for PE teachers (Metzler, 2011; Rink, 2014; Siedentop & Tannehill, 2000; Ward et al., 2021), graduates of the SSM program will also embark on careers in sports coaching and will require skill analysis training. Thus, the inclusion or incorporation of skill analysis training should be considered by both the administrators of PETE and SSM programs.

Interestingly, there was a small but statistically significant increase in skill analysis ability scores between the pre-test and post-test for the SSM undergraduates. Although the SSM undergraduates did not receive any information or training regarding skill analysis from the investigators, they continued to read university courses such as Introduction to Growth and Motor Development, where one of the learning outcomes was to "observe, analyze, categorize, and discuss children's fundamental movement skills." Thus, the increase in scores can be attributed to the university courses they read, but the courses did not enable them to reach the established level of 80% for skill analysis to be considered competent (Kelly & Moran, 2010; Walkley & Kelly, 1989; Williams & Tannehill, 1999). This finding corroborates past studies that cautioned against the inadequacy of specific university courses in equipping participants with the ability to analyze skills (Knudson, 2013; Overdorf & Coker, 2013).

Most crucially, the pre-service PE teachers attained the established level of 80% for skill analysis to be considered competent (Kelly & Moran, 2010; Walkley & Kelly, 1989; Williams & Tannehill, 1999) after the skill analysis training program. This finding is unprecedented, as no studies involving more than six motor skills have their participants attain competency after training. For example, Williams and Tannehill (1999) reported that participants' skill analysis ability improved but did not attain competency after training them on nine motor skills. Pulling and Allen (2014) reported that participants' skill analysis ability did not improve after training them on six motor skills. Haynes and Miller (2015) did not report the participants' competency level after training them to analyze seven motor skills.

Retention of Skill Analysis Ability

The second research question was whether the pre-service PE teachers retained their skill analysis ability six weeks after the training program, and it was hypothesized that their skill analysis ability

would be retained six weeks after the training program. The statistically insignificant result between the post-test and retention scores indicated that the hypothesis was supported. More importantly, the pre-service PE teachers maintained the established level of 80% for skill analysis to be considered competent at retention (Kelly & Moran, 2010; Walkley & Kelly, 1989; Williams & Tannehill, 1999). This study's findings contribute to extant literature as prior studies indicated that skill analysis ability is retained after a week (Kelly et al., 2012), two weeks (Eckrich et al., 1994), and two months (Morrison & Harrison, 1985), but not one year later (Wilkinson, 1992).

Despite the contribution of this study, the retention of skill analysis ability remains understudied, and future research will aid PETE program administrators in program design. For example, PETE programs in Singapore (National Institute of Education, 2020a, 2020b, 2020c) typically consist of four semesters, spanning two years. As research indicated that skill analysis ability is retained within two months but not one year later, program administrators should schedule their skill analysis training program in the last semester so that pre-service PE teachers' skill analysis ability remains viable upon graduation. Alternatively, future research should examine whether skill analysis ability is retained after six months or more, and when additional skill analysis training should be scheduled to aid retention, and whether a full or reduced skill analysis training program is required to maintain one's skill analysis ability.

This study is not without its limitations. First, the study's context and the small number of participants necessitated the use of a quasi-experimental research design, which limited the generalizability of the study's findings. Specifically, fewer than 50 pre-service PE teachers are recruited and trained in Singapore annually. Future studies should employ true experimental research designs to better control threats to internal validity (Thomas et al., 2011). To address the number of participants, future research should either employ a longitudinal design to recruit more cohorts of pre-service PE teachers over several years or recruit participants from other universities with PETE programs. Lastly, this study only involves eight motor skills. While the number of skills involved in this study already exceeds that of most existing literature studies, it pales in comparison to the plethora of motor skills that PE teachers must analyze (Kelly &

Moran, 2010). Future research should examine the training and PE teachers' analysis ability in motor skills not addressed in past studies.

Conclusion

This study aimed to examine the effects of a training program on pre-service PE teachers' skill analysis ability. It was found that the pre-service PE teachers' skill analysis ability improved after the training program, and their ability was retained six weeks after the training program. More importantly, the training program enabled the pre-service PE teachers to not only attain but also retain the established level of 80% for skill analysis to be considered competent (Kelly & Moran, 2010; Walkley & Kelly, 1989; Williams & Tannehill, 1999) for eight motor skills. No previous studies involving more than six skills have enabled their participants to be proficient in skill analysis. Additionally, it was found that both pre-service PE teachers and SSM undergraduates struggled to analyze motor skills. Thus, this study supports the inclusion or incorporation of skill analysis training by the PETE programs as well as the SSM program in Singapore.

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