International Journal of Sport Culture and Science
December 2024 : 12(4)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2024.722

Perceived Effectiveness of a Skill Analysis Training Program for PE Student Teachers

Shern Meng-TAN[1]
[1]Nanyang Technological University, Singapore, Singapore
https://orcid.org/ 0000-0003-1483-9619

Email: shernmeng.tan@nie.edu.sg

*Type: **Research** Article (Received: 29.05.2024– Accepted: 11.10.2024)*

Abstract

Although skill analysis is important for physical education (PE) teachers, its training is underemphasized by the physical education teacher education (PETE) programs in Singapore. This study aims to examine the perceived effectiveness of the skill analysis training program, and ten pre-service PE student teachers who completed the skill analysis training program were interviewed. Data was analyzed using a thematic approach and six themes within the sub-categories of strengths, weaknesses, and suggestions to the skill analysis training program emerged: (1) Videos of correct skill performances facilitated participants' learning, (2) Learning activities enabled participants to analyze skills, (3) Checklists alone do not enable skill analysis, (4) Lack of opportunities for real-time skill analysis, (5) Combine learning activities 1 and 2, and (6) Provide opportunities for real-time skill analysis. Specifically, future skill analysis training programs should be instructor-led as pre-service PE teachers need guidance, participants should be provided with a clear understanding of the skill by providing checklists and correct skill performance videos simultaneously, and existing skill analysis attempts should be technology-aided until further research ascertain the effective transfer from video-based skill analysis to real-time.

Keywords: Fundamental movement skills, Movement analysis, Physical education teacher education, Qualitative movement diagnosis

Introduction

Skill analysis is an important ability that PE teachers must possess as they rely on it to provide feedback, manage the classroom, and inform teaching practice (Metzler, 2011; Rink, 2014; Siedentop & Tannehill, 2000). Skill analysis refers to the systematic observation and introspective judgment of the quality of the human movement to provide the most appropriate intervention to improve performance (Knudson, 2013), but its training has been understudied for the past decades. For example, past research indicated that videotape-based instruction complemented with skill checklists was effective for pre-service PE teachers (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). More importantly, few studies 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).

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

Researchers have proposed that PETE programs depart from the traditional but fragmented approach of skill analysis training (Overdorf & Coker, 2013) and adopt an interdisciplinary approach instead. Moreover, skill analysis training should be incorporated into instructional courses and supported by technology (Ward et al., 2021). For example, Knudson and his colleagues 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 (Knudson, 2000, 2013; Knudson & Morrison, 1996). For this skill analysis model, PE teachers must first prepare to analyze the skill by identifying its performance criteria from research, professional literature, and experience. Next, PE teachers should observe multiple attempts of the skill and from positions where he/she can see most/all of the performance criteria. After observing, PE teachers evaluate/diagnose the skill performance by determining whether the performance criteria were performed correctly, incorrectly, or absent. Last, PE teachers remediate the skill performance either by providing feedback to the performer or modifying the task.

Situated in Singapore's PETE programs, this study is one of the first studies examining 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. Specifically, this study aimed to examine the perceived effectiveness of the skill analysis training program.

MATERIAL AND METHOD

Research Design

Qualitative case studies are intense investigations of a bounded system, focusing on an identified issue, collecting data only from those involved in the bounded system, and providing a rich description of it (Pitney & Parker, 2009). Using the qualitative case study research design, the skill analysis training program is considered as the bounded system, and data is collected from the participants via interviews.

Skill Analysis Training Program

Premised on Knudson's (2013) four-task model, i.e., preparation, observation, evaluation and diagnosis, and intervention, the skill analysis training program comprised four learning activities. The first and second learning activities were based on the first task of preparation. The third and fourth learning activities were based on the second task of observation, and the third task of evaluation and diagnosis. The skill analysis training program did not address the fourth task of intervention as the participants were not required to propose interventions to correct the errors observed in the skill performance videos.

For the first learning activity, the instructor provided participants with criteria sheets containing illustrations and critical features of eight identified skills and introduced the skills' sequences and performance criteria. 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 performance criteria ranged from five to eleven for each skill.

For the second learning activity, the instructor showed participants correct skill performance videos of the eight identified skills, i.e., all the skill performance criteria are present and performed correctly. The correct skill performance videos were first shown in real-time and without the instructor's comments to give participants an overall impression. Subsequently, the videos were shown in slow motion or freeze-frame, and the instructor highlighted the performance criteria whenever they occurred.

For the third learning activity, the instructor showed participants incorrect skill performance videos of the eight identified skills, i.e., some of the skill's performance criteria were absent or performed incorrectly. The incorrect skill performance videos were first shown in real-time and without the instructor's comments to give participants an overall impression. Subsequently, the videos were shown in slow-motion or freeze frame, and the instructor highlighted the erroneous or missing performance criteria whenever they occurred.

For the fourth learning activity, the participants were provided with incorrect skill performance videos of the eight identified skills and tasked to rate them before comparing their ratings with the instructor. Participants were afforded the use of slow-motion and/or freeze-frame functions when rating the incorrect skill performance videos.

The skill analysis training program adopted a typical university course schedule for three weeks, i.e., 3-hour sessions per week (see Figure 1). 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. Participants' skill analysis ability was measured before (pre-

test), immediately after (post-test), and six weeks after (retention test) the training program, and their test scores were analyzed and reported in another study.

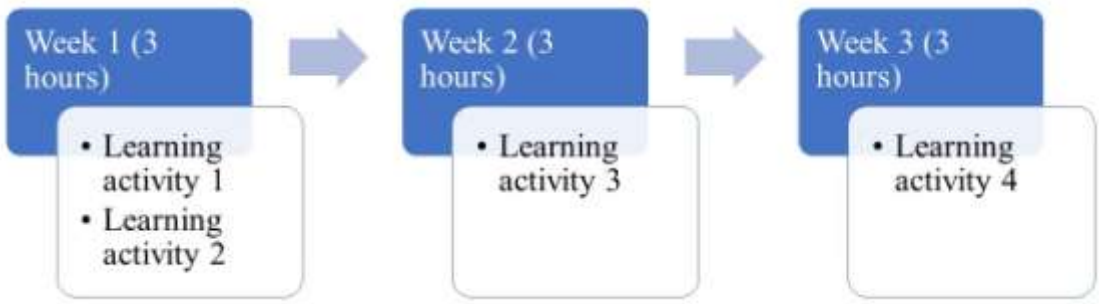

Figure 1. Skill analysis training program

Participants

Ten pre-service physical education teachers (3 males, 7 females, mean age 26.9 ± 5.55 years) participated in this study (see Table 1). Participants for this study were purposively sampled because of their ability to answer the research question (Teddlie & Yu, 2007), i.e., all the identified participants completed the skill analysis training program and attained the established level of 80% for skill analysis to be considered competent (Kelly & Moran, 2010). This study was approved by the investigator's university institutional review board (IRB-2020-06-031) and the participants provided signed informed consent.

Table 1. Details of participants

Participant	Gender	Age	Post-test score (%)
1	F	20	91.18
2	F	24	92.65
3	F	23	92.65
4	M	40	91.18
5	M	27	91.18
6	F	24	92.65
7	F	31	91.18
8	M	26	92.65
9	F	25	95.59
10	F	29	91.18

Procedure

All the interviews were conducted during the first quarter of 2021 (January to March) at a time convenient to the participants, and the interviews ranged between 37.33 to 62.45 minutes (mean duration 52.51 ± 8.78 minutes). The semi-structured interviews sought participants' perceived effectiveness of the skill analysis training program, i.e., which learning activity enables you to analyze skills and why? Follow-up questions sought participant's perceived shortcomings of the skill analysis training program, i.e., which learning activity did not enable you to analyze skills and why? The interviewer also sought their suggestions to improve the skill analysis training program, i.e., what other learning activities do you think will enable you to analyze skills and why? Each interview was audio-recorded and transcribed verbatim.

Data Analysis

Adopting a four-phase approach (Creswell, 2013), the interview transcripts were analyzed and interpreted using the constant comparative method. The four phases comprised: (1) organizing the data, (2) reading and making memos, (3) describing, classifying, and interpreting data into codes and themes, and (4) representing and visualizing the data. First, data is organized by electronically storing the transcripts as Word documents and systematically naming them. Second, all the Word documents are read in their entirety several times to gain a sense of the whole database, with memos, i.e., short phrases, ideas, or key concepts, written to help in the exploration of the whole database, and to form initial codes. Third, information that is expected to be found (based on existing research), surprising information that is not expected to be found, and information that is conceptually interesting or unusual are coded and further reduced into a small, manageable set of themes. Last, themes were interpreted within a combination of personal views and the research literature and visualized as a hierarchical tree diagram.

FINDINGS

Based on the participants' responses, their perceived strengths and weaknesses, as well as suggestions for the skill analysis training program, are categorized into the following themes: (1) Correct skill performance videos facilitated participants' learning, (2) Learning activities enabled participants to analyze skills, (3) Checklists alone do not enable skill analysis, (4) Lack of opportunities for real-time skill analysis, (5) Combine learning activities 1 and 2, and (6) Provide field experiences for real-time skill analysis (see Figure 2). Each theme is explained in the following sections.

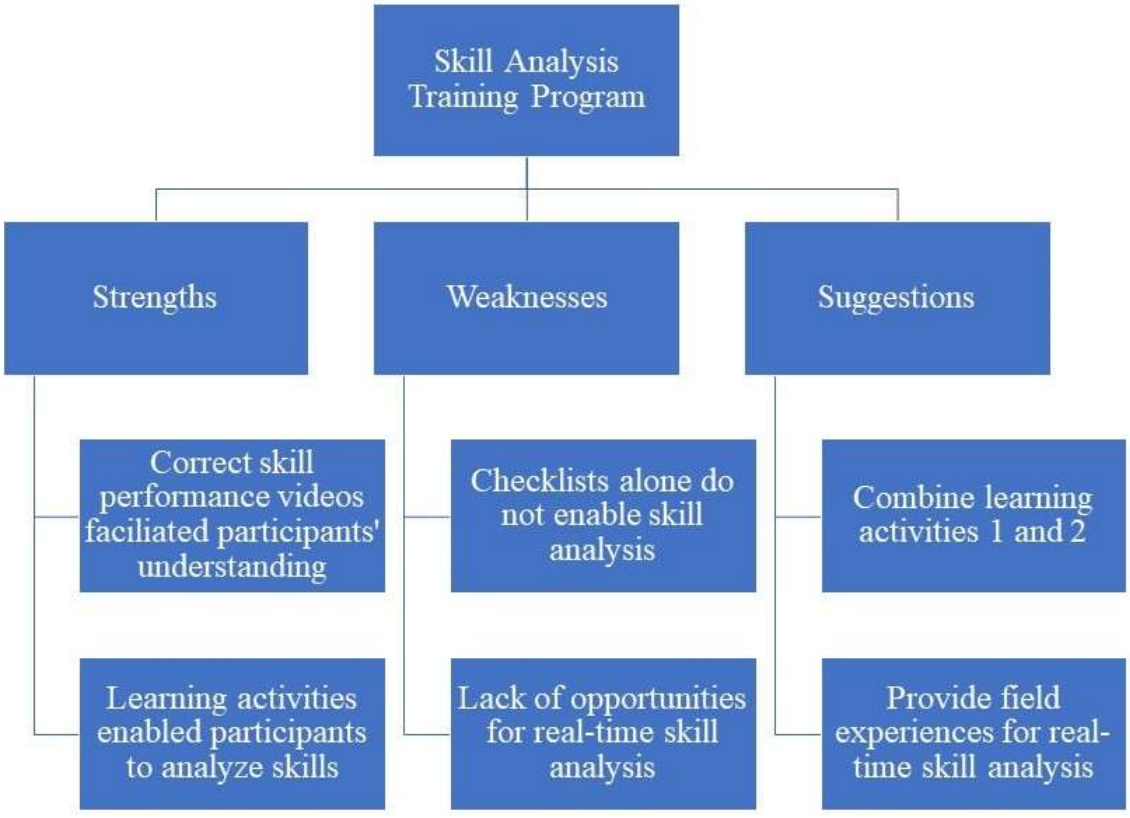

Figure 2. Participants' Perceptions of the Skill Analysis Training Program

Correct Skill Performance Videos Facilitated Participants' Understanding

The first strength of the skill analysis training program was the skill performance videos. Slightly more than half of the participants found the correct skill performance videos important for their learning. With the skill checklists, participants must mentally visualize how the skills are performed. Conversely, participants were able to watch how the skills were performed and where each of the performance criteria occurred during the correct skill performance videos. For example:

I think I'm confident enough to analyze skills because the correct skill performance videos provide me with a guide. Once I'm clear with the set of movements from the resources provided, it makes no difference to me if I've to analyze any students' skill performances (Participant 4).

The videos provided us with a very accurate description of the checklist, it's a lot easier to analyze someone with the checklist and the video. I became familiar with the skill after viewing the video 3 to 5 times, especially when I can playback the video in slow motion (Participant 9).

An additional benefit of the correct skill performance videos was the affordance of video functions, i.e., freeze-frame, and slow-motion, that enabled the participants to gain a better grasp of the skill performance and its performance criteria, as opposed to watching the skill performance in real time. For example:

Watching the correct skill performance videos gave me a mental image of the skill and when I can see the flow I can kind of keep it in my head faster. Also, after I see the video, I realized that there are some performance criteria that are simultaneous. Pausing the video during the performance criteria really helped because it was hard to see some performance criteria when the video was played at real-time speed (Participant 1).

I will be somewhat confident to watch students' skill performances and check whether the performance criteria are there or not, but I will need the student to perform the skill several times because unlike the video, I cannot replay their performances and check the performance criteria one by one. I prefer the skill performance videos to live skill demonstrations, because I need to slow down or stop the skill performance so that I can check off each performance criteria, and make sure I understand them (Participant 6).

From the videos, I could see some of the performance criteria that I couldn't tell from the pictures alone. Also, I could play the videos in slow motion because some of the performance criteria are so fast that I wouldn't be able to see in real time. If I don't understand any of the performance criteria, I will review the video to see how the criteria is performed (Participant 10).

Interestingly, the correct skill performance videos also allowed participants to check on their own skill performances. For example:

The correct skill performance videos helped me when I was able to view them while looking at the checklists. Also, I used the correct skill performance videos to check my own skill performances because I have to know the performance well to be able to breakdown the performance part by part and tell myself what to focus on. (Participant 2).

Learning Activities Enabled Participants to Analyze Skills

The second strength of the skill analysis training program was the learning activities. Most of the participants perceived that the third learning activity enabled them to analyze skills. Some participants highlighted that the third learning activity provided them the opportunity to

compare their skill analysis to the instructor and to clarify their doubts with the instructor. For example:

Although I don't agree with some of the instructor's analysis, I'm okay to go along with his perspective. I'm not really a professional yet, and I can't be 100% sure that what I agree on is the right one. I've to get used to this because I have to make sure my analysis is the same throughout because everyone in my department is going to follow this (Participant 2).

From this activity, I could see how students performed these skills and it gave me a chance to check back using the performance criteria that were provided and compare my skill analysis with the instructor (Participant 4).

I found this activity tough initially because the performance criteria were interpreted differently by me, the others, and the instructor. It was the discussions and clarifications that helped me really understand the performance criteria and the rest to arrive at a common ground. It is when I really talked it out with the instructor and understand what each performance criterion and the picture really mean (Participant 6).

In addition, some participants gained a better grasp of the skills' performance criteria after the third learning activity when they watched the incorrect skill performance videos. For example:

I would say this activity helped me a lot. I was able to better understand the performance criteria as there were performance errors in the students' skill performance videos. I prefer the students' skill performance videos because it is what I will be observing in the future (Participant 3).

During Activity 2, I just match the performance criteria to the skill performance video when it occurred. For this activity, I really had to watch the students' performances and process whether the student perform each criterion or not. Also, the practice really helped when I watched several students' performance videos (Participant 7).

Interestingly, the incorrect skill performance videos performed by students not only gave the participants a sense of what to expect from students when they teach in schools but also the variety of skill performance errors that students might portray. For example:

After this activity, I am like 90-95% confident to analyze skills because I now know from the students' skill performance videos how a student might perform in a realistic setting and what's right or wrong in each performance. I think I will be most confident after I start teaching students and gain more experience in analyzing their skill performances (Participant 5).

This was the most helpful activity for me because the main issue I had was to decide whether the students' skill performance meet the performance criteria or not. Also, I've never really got a chance to observe primary school students performing these skills and they came up with all sorts of different patterns that I didn't except during their skill performance videos (Participant 8).

I used to assess students' performances based on my past experiences and I found it very hard for me to help them improve because I couldn't identify what went wrong with their performances. Also, the videos of students' performances gave me a sense of how students will perform, and the possible areas where students can make mistakes during their performances (Participant 9).

The videos provided an experience of what's really happening on the ground when you assess them based on the performance criteria. Also, I could play the videos in slow motion, stop the videos at certain junctures, and replay the videos as often I require (Participant 10).

The participants unanimously perceived that the fourth learning activity enabled them to analyze skills, allowed them to apply what they have learned during the skill analysis training program, afforded them more time to analyze the students' skill performances, and imbued confidence in their skill analysis. Specifically, the fourth learning activity provided them the opportunity to align their analysis with the instructors, compare their analysis with peers, and understand why skill analysis might differ between themselves and others. For example:

This activity was useful when it came to my speed in checking and identifying the performance criteria. I tend to slow down, pause, and overthink when it comes to whether I should mark the students' skill performances as right or wrong. But then, I just told myself to think about the model answer and be ruthless (Participant 1).

This was definitely useful because it allowed me to compare my skill analysis with the other participants during the discussion. It helped me to be uniform in terms of our analysis because in schools, skill analysis varies between different teachers (Participant 4).

Most importantly, participants saw the fourth learning activity as an opportunity to apply what they had learned during the skill analysis training program. For example:

Activity 4 gave us the opportunity to apply what we learnt, and when I tried to apply, I have questions. I personally think this is better because I can bring my questions back to the instructor and this is much closer to the real classroom experience than Activity 3. Also, I had time to playback the students' skill performance videos in slow motion and real time and compare them with the correct skill performance videos when I needed to (Participant 6).

The individual practice allowed me to apply what I have learnt from the previous activities. At home, I had time to playback the students' performance videos in real time, slow motion, and stopping it whenever I needed. Also, I was able to watch the correct skill performance videos again to compare with the students' performance videos. Checking my responses with the instructor at the end enabled me to look at the students' skill performance videos from a different perspective when my responses were different from the instructor (Participant 7).

Unlike the third learning activity which was instructor-led, the fourth learning activity was self-directed, i.e., participants were given access to the incorrect skill performance videos and completed the skill analysis on their own time. This provided them with more time to better analyze the skills with the affordances of the video functions. For example:

It's just as effective as activity 3 but maybe I got a bit more time to watch the videos multiple times, pause it at certain points, and play it back in slow motion (Participant 8).

I treated it as more practice for me to analyze the skills and being able to take the videos back home gave me more time to look at the videos in real time and in slow motion (Participant 9).

The videos allowed me to interpret the performance criteria against actual students' performance. Like activity 3, I could play the videos in slow motion, stop the videos at certain junctures, and replay the videos as often I require (Participant 10).

In turn, participants were more confident with their skill analysis ability after the fourth learning activity as they progressed through the skill analysis training program and could see their improvement in terms of analyzing skills. For example:

I was quite stressed at the start of the training program because I don't know which performance criteria is right, which is wrong. Having gone through the previous activities, I found this activity easier for me because I'm confident in checking the performance criteria when I watched the videos (Participant 2).

I took a lot of notes during Activity 3 and I was able to confidently analyze the students' skill performances during this activity. I could see the improvements that I made where I was able to get more rights than wrongs during the discussion (Participant 3).

This activity was very helpful even though I spent quite a bit of time doing it, especially when we came back and discuss a bit more on the performance criteria. I think I was pretty confident to analyze the skills after the activities (Participant 6).

Checklists Alone Do Not Enable Skill Analysis

The first weakness of the skill analysis training program was the checklists. Most of the participants did not perceive that the skill checklists alone enabled them to analyze skills. Specifically, the performance criteria and illustrations were not as clear for them. For example:

I think my confidence to analyze skills will be low because of the interpretation of the words. There's a gap between reading the words and watching the skill performance videos to know what exactly I'm supposed to look for. Some performance criteria were clear to me, but I really didn't understand some (Participant 4).

Although the checklist is quite detailed, but it doesn't say how smooth the motion is like. I didn't really understand how some performance criteria were supposed to look like even when I looked at the pictures (Participant 9).

Participants perceived that the skill checklists alone did not give them a good grasp of the skill performance and were concerned with the discrepancy in the analysis they might make when their analysis is compared with others. For example:

I would say this activity alone is insufficient because I won't be able to see how the movements are carried out or how different students might carry out the movements. There was nothing much for me to understand from the checklists other than the words, and my analysis might be different for each student I observed (Participant 3).

I'll not be too confident to analyze the skills because the checklists' performance criteria do not give me a good grasp of how the skill actually look like. Although the performance criteria are quite clear, there is still discrepancy or ambiguity how the skill is analyzed (Participant 8).

By only looking at the pictures and performance criteria, I think two different persons can interpret this differently and whether the performance meet the criteria or not. Also, having only the pictures and performance criteria may be sufficient for a person with knowledge of the skills, but it will not be sufficient for a person without knowledge of the skills (Participant 10).

Interestingly, two participants perceived that the skill checklists alone enabled them to analyze skills because the performance criteria were simply worded and easily understood, and the illustrations allowed them to visualize how the skills were performed. For example:

It is not difficult to analyze skills with only the checklists because it's in simple English, there's no jargon, and I would be certain with how I look at things. It's more like there's different interpretations to the performance criteria and I don't want to cause confusion to my students, e.g., if I say his performance is wrong, but another teacher says that his performance is correct (Participant 1).

With the pictures in the checklists, I can gauge, imagine, and act out how the movement looks like. I think I can understand the performance criteria better because they are put in words as well. Some people would think differently on how the movement might look like, but that's probably a minor thing, and it doesn't impact a lot (Participant 2).

Lack of Opportunities for Real-Time Skill Analysis

The second weakness of the skill analysis training program was the lack of real-time skill analysis. As the skill analysis training program did not require participants to propose interventions to correct the errors observed in the videos, they saw it as a shortcoming and proposed that peer-based and real-time experiences be included in future iterations of the program. First, participants can practice by analyzing their peers' skill performances either via video or in real time. For example:

Video record and analyze fellow participants' skill performances. Since we need to demonstrate the skills to our students in the future, we need to get it right first. So, we get to practice performing our skills and analyzing each other's skills. The participants' skill performance videos should be analyzed by several participants and the instructor, and then discussed (Participant 2).

Get my fellow participants to perform the skills and analyze their skill performances in real time, without the use of video playback functions. When it's on a video, I have the luxury of slowing down or pausing the skill performances. Doing skill analysis in real time will really train us to catch the speed of the skill performance and become confident and comfortable to analyze skills in real time (Participant 6).

Combine Learning Activities 1 and 2

The first suggestion was to combine the learning activities. Some of the participants who did not perceive that the skill checklists alone enabled them to analyze skills suggested that they need to watch the skill performance, either on video or in real time, to better grasp how the skill is performed before they can analyze it. For example:

With the checklists alone, I would say that I'm 50% confident because it just made half the process easier for me. Without any skill performance videos, it's quite hard for me to visualize the whole process. With only the pictures and performance criteria in the checklists, I can only imagine how the skill performances will look like, but I don't know that this is the correct thing for sure (Participant 5).

The checklists are just a sequence of pictures and words to me. Seeing the skill being executed in real time or through a video would really help me to understand the performance criteria better. Specifically, I want to watch the correct skill performance and match it to the different performance criteria that are on the sheet of paper (Participant 6).

Although the checklists have pictures and performance criteria, I need to see the skill performance and see how the performance criteria come together into the skill before I can analyze a skill (Participant 7).

Having experienced the first and second learning activities separately, participants suggested that the two learning activities should be combined so that the skill checklists and correct skill performance videos are made available simultaneously to future participants. It was also suggested that the first and second learning activities be made available ahead of the skill analysis training program. For example:

Combine Activities 1 and 2. I prefer to see the correct skill performance videos immediately and together with the checklist (Participant 3).

Instead of separate activities, Activity 1 and 2 can be combined so that the pictures, performance criteria, and the correct performance are shown simultaneously and coherently (Participant 10).

Instead of conducting them during the training program, Activities 1 and 2 can be conducted before the start of the training program. I think I'm able to watch the correct performance video and match the performance criteria on the checklist on my own (Participant 9).

Provide Field Experiences for Skill Analysis

The second suggestion was to include opportunities for real-time skill analysis. Addressing the perceived weakness of the skill analysis training program, participants further suggested field experiences to analyze students' skill performances. Specifically, they needed to know whether they could analyze students' skill performances in real time and conduct skill analyses for a class of students. For example:

Having to analyze 1 class of students' skill performances. I only got to analyze 10 students' skill performances, and I wanted to see more variety. Also, I know that to have 20 or 30 students is a lot to do but this is my bread and butter and I want to know I can analyze 1 class properly (Participant 5).

Going to a school and analyze students' skill performances in real time or having to analyze 1 class of students' skill performance videos, and students of different body types. The current videos cover the average student, but I think it will be very interesting to see how a taller or shorter student perform the skills (Participant 8).

Observing students' performances in real time and not having the option to pause the video. Once I am posted to the school, I can't always video record students' performances or get them to do it again, so it's a good platform to practice. Also, my observation and analysis should be checked by the instructor or a peer (Participant 10).

DISCUSSION AND CONCLUSION

This study aimed to examine the perceived effectiveness of the skill analysis training program, and ten participants who completed the training program were interviewed. In this section, the strengths, weaknesses, and suggestions for the skill analysis training program are discussed.

The perceived strengths of the skill analysis training program were that skill performance videos facilitated participants' learning, and learning activities enabled participants to analyze skills. In terms of the skill performance videos, participants found them useful as they need not mentally visualize the skill using the skill checklists. In addition, the video functions, i.e., slow-motion and freeze frame, allowed them to better grasp the skill and its performance criteria. This finding is consistent with previous studies where video technology has enhanced skill analysis training (Walkley & Kelly, 1989). For example, Kelly and his colleagues have consistently relied on skill performance videos for skill analysis training among pre-service

and in-service PE teachers (Kelly & Bishop, 2013; Kelly & Moran, 2010; Kelly et al., 2012; Walkley & Kelly, 1989; Wilson et al., 2021). Although the participants did not attain skill analysis competency in some of their studies, all the participants demonstrated improvement when skill performance videos were used in their skill analysis training programs.

In terms of learning activities, participants highlighted that they were able to observe how the instructor analyzed the skills, compare their analysis against the instructor, and clarify their doubts immediately during the instructor-led activity. The importance of the skill analysis training program's instructor cannot be understated as McKethan et al. (2003) found that a computer-based training program without an instructor was ineffective in improving participants' skill analysis ability. Moreover, Kelly and his colleagues found that the instructor's presence was more important for pre-service than in-service PE teachers as the instructor's guidance was imperative for pre-service PE teachers, i.e., they completed fewer attempts when assigned self-directed practices, and attained lower competency in skill analysis (Kelly & Bishop, 2013; Wilson et al., 2021). Like the correct skill performance videos, participants found the incorrect skill performance videos useful as they were better able to identify the skills' performance criteria and anticipate the errors school students will make when performing the identified skills. This finding is congruent with Gangstead and Beveridge (1984) as they found that knowledge of the correct skill performance alone may not improve skill analysis ability but the availability of correct and incorrect skill performances improved skill analysis ability. Lastly, participants highlighted that practice was the key affordance for the self-directed activity as they used the video functions more and repeatedly watched and compared the correct and incorrect skill performance videos. This finding is consistent with previous studies as experience and familiarity with the skill provide an advantage to skill analysis ability, i.e., coaches were better able to analyze skills than PE teachers as they do it daily (Imwold & Hoffman, 1983), and participants who completed more attempts of self-directed practices attained higher competency in skill analysis (Kelly & Bishop, 2013; Wilson et al., 2021).

The perceived weaknesses of the skill analysis training program were that checklists alone do not enable skill analysis, and the program lacked opportunities for real-time skill analysis. In terms of the checklists, participants were mainly concerned with their interpretations of the illustrations and performance criteria to analyze the skills correctly. Consequently, the participants have suggested that checklists and correct skill performance videos be introduced simultaneously to alleviate this weakness, i.e., combine learning activities 1 and 2. Prior studies have always introduced checklists and skill performance videos simultaneously when training participants to analyze skills. For example, Wilkinson (1996) and Wilson et al. (2021) simultaneously taught participants the criteria and showed both correct and incorrect skill performance videos as part of their tutorials for the overhand throw and underhand roll respectively. After observing many PE lessons where school students never received skill analysis training but were provided checklists and expected to analyze their peers' skill performances, the investigator often questioned whether such practice was pedagogically sound. Therefore, separating the provision of skill checklists and skill performance videos provided the opportunity to examine whether participants can analyze skills when only provided with skill checklists. This study's findings demonstrated that skill checklists alone do not enable one to analyze skills and training is essential for such ability. Therefore, it is not only crucial that pre-service PE teachers receive skill analysis training for effective PE teaching but also imperative that PE teachers cease the practice of providing skill checklists to school students and expect them to analyze their peers' skill performances without training.

In terms of opportunities for real-time skill analysis, participants suggested that the skill analysis training program should include such opportunities. As PE teachers-to-be, the participants were aware that they would be required to analyze their students' skill performances during their lessons. Unfortunately, prior studies indicated that video-based skill analysis training does not transfer well to real-time skill analysis. For example, Eckrich et al. (1994) found that video-based skill analysis training did not improve real-time skill analysis, attributing their findings to environmental differences. While the video only showed a few students, participants were distracted by larger spaces, more students, and more ongoing activities in the real-time environment. Likewise, Haynes and Miller (2015) reported significant differences between the real-time and video analyses, indicating that participants were more accurate in their skill analysis via video recordings than in real-time. While more research is required to better understand the transfer of video-based skill analysis training to real-time skill analysis, two possible solutions have been proposed. First, more time is spent on skill analysis training so that PE teachers transit progressively from video-based to real-time, by first focusing on simple skills before complex skills, and by first analyzing a few students before the entire class (Eckrich et al., 1994). Second, it was recommended that PE teachers avoid the frailties of real-time skill analysis and utilize technology-aided skill analysis since smartphones and inexpensive digital cameras are readily available (Haynes & Miller, 2015).

In conclusion, this study provided further evidence that skill analysis training is essential for pre-service PE teachers, highlighted the program's strengths and weaknesses, and identified possible improvements to the program. Specifically, pre-service PE teachers learning to analyze skills should be simultaneously exposed to its criteria as well as correct and incorrect skill performance videos, and the program for pre-service PE teachers should be instructor-led as they require guidance. Consequently, neither pre-service PE teachers nor school students should be provided with skill checklists and expected to analyze the skill performances of their students or peers respectively. While further research is required to better understand the transfer of skill analysis from video-based to real-time, PE teachers can still rely on technology-aided skill analysis using their smartphones and digital cameras. Finally, this study not only contributes to the limited literature on skill analysis training but also supports the inclusion or incorporation of skill analysis training by the PETE programs.

Acknowledgments

The author would like to thank the participants of the study and Associate Professor Tan Kwang San Steven for his guidance in the preparation of the manuscript.

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