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The Effects of Adopting Tablets and Facebook for Learning Badminton Skills: A Portfolio-Based WISER Model in Physical Education

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ABSTRACT: To improve the badminton skills learning of students, this study proposed the portfolio-based WISER model, which combines tablets for instantaneous recording and Facebook for e-portfolios. The 97 learners in the experimental group (EG) were taught with tablets and Facebook, and the 102 learners in the control group (CG) were taught with traditional teaching methods. The paired sample t test and ANCOVA were used for statistical analysis. The posttests of smashing and footwork in the EG and CG were both significantly higher than those on the pretests. The posttest scores for smashing were significantly higher in the EG than those in the CG. For pretest scores were higher than 7.66 or lower than 5.09, the posttest footwork scores were significantly higher in the EG than in the CG. The proposed portfolio-based WISER model can help students reinforce their understanding of badminton skills and improve their skill learning.

Keywords: Tablets, Social media, Badminton, Motor skill learning, e-portfolio

1. Introduction

Physical education (PE) is an essential subject for students' growth and health. Instructor meet the difficult challenge of balancing the complexity (typically one physical skill contains many detailed movements), spatiality (coordination of different body parts), precision, and speed of teaching contents (McKenzie & Lounsbery, 2013). The combination of technology and education is a current trend in PE. With the development of new technology, researchers now can apply 3D animation, multimedia websites, and online learning systems to assist PE teachers (Lan, Wang, & Chen, 2010; Papastergiou & Gerodimos, 2013; Zou, Liu, & Yang, 2012). The multimedia tools used in the aforementioned studies, however, must be operated in front of computers rather than during lectures. To solve this problem, our previous study applied tablets as instantaneous feedback tools and showed that tablets enabled the student to quickly comprehend how to correctly perform the skills being taught (Hung, Young, & Lin, 2018). Moreover, the related research has confirmed our previous study and highlighted the potential relevance of using video feedback in fostering motor learning engagement and motivation (Potdevin et al., 2018). Therefore, further research is needed to provide greater freedom to obtain visual feedback during the learning process.

In the meantime, social media has changed not only the means through which people communicate but also personal habits of sending, receiving, and sharing information (Magogwe, Ntereke, & Phetlhe, 2014; Wise, Skues, & Williams, 2011). According to a Statista report, more than 3.6 billion people worldwide use social media (Statista, 2020). Social media platforms, such as Facebook, have become daily essential tools for the younger generation growing up with the Internet and these platforms play an important role in many people's lives (Statista, 2020). For university students, Facebook helps maintain social relationships through continuous use (Raza, Qazi, & Umer, 2017).

Facebook has been explored in the application of education by many researchers. Some research has indicated that integrating Facebook into education has positive effects on student learning (Kabilan, Ahmad, & Abidan, 2010; Deng & Tavares, 2013; Magogwe et al., 2014). Magogwe et al. (2014) found that students often discuss course projects on Facebook, share course-related materials with their classmates, and ask questions to clarify lecture concepts. These results are also similar to those obtained by Deng and Tavares (2013), which demonstrated that Facebook helps to extend class discussions beyond the classroom. Kabilan et al. (2010) likewise indicated that using Facebook in class motivates students to learn, participate, and interact with their peers. Moreover, as a learning management system, Facebook is easily operated and accessible through mobile phones (Magogwe et al., 2014).

For this reason, this study adopts Facebook as a learning management system and proposes an innovative learning approach that uses Facebook Messenger to create e-portfolios of students' badminton skill learning. Through the interactive function of Facebook Messenger, instructors and learners can easily send one another information. At the same time, an e-portfolio is utilized for the collection of digital data regarding a student's learning progress, including texts, audio tracks, videos, and images. These digital data may also include feedback from experts or peers, the opinions of learners formed during the learning process, or later through introspection (Chang, 2014; Chu, 2009). Chang (2014) further pointed out that e-portfolios help students set learning objectives, accumulate knowledge, and consequently enhance their learning performance. In addition, Melograno (2000) claimed that student learning in PE needs to be evaluated in a more natural and performance-based manner, emphasizing the importance of recording students' growth in learning.

In view of the remarkable capability of tablets to provide instantaneous feedback, and the accessibility of Facebook Messenger, the aim of this research is to provide possible solutions to the existing problems in PE teaching, and eventually to facilitate badminton skill acquisition through the application of common handheld technologies and social media. This study intends to explore how tablets and Facebook can be integrated to form an innovative approach in an authentic learning setting. The main research objective is to understand the effects of the combination of tablets and Facebook to create e-portfolios on badminton learning. In order to reach this objective, an innovative approach is applied to PE courses to introduce a new perspective on PE teaching.

In this study, smashing and footwork were selected as the target learning skills due to their higher difficulty of acquisition. Smashing was also selected because it plays a key role in scoring in female doubles games (Tsai, Liao, & Chen, 2016). Footwork was chosen because the agility of footwork is the basic foundation of badminton (Chang, Chang, Chen, Ho, & Chen, 2016). Based on the research objective and the two badminton skills selected, this study poses two research questions:

(1) What are the effects of adopting tablets and Facebook on learners' badminton smashing performance?
(2) What are the effects of adopting tablets and Facebook on learners' badminton footwork?

2. Literature review

2.1. Motor skill acquisition in physical education

PE provides positive and profound effect for students in physical, lifestyle, affective, social, and cognitive domain to enhance their health (Bailey, 2006). PE focuses on learning through exploratory operations and requires repeated exercises of motor skills. Different from perception and cognitive skills, motor skills are a set of internal processes combined with repetitive exercises (Gagné, 1984; Newell, 1991; Schmidt & Lee, 1999). To gradually automate the skills, the acquisition of motor skills can be introduced from three stages: the cognitive stage, the association stage and the autonomy stage (Fitts & Possner, 1967).

In the cognitive stage, learners focus on executing skills and discovering what to do (Schmidt & Lee, 1999). Because this stage includes the learner's conveyance and acquisition of new information, this stage is also called the speech movement stage (Adams, 1971). In this stage, learners collect information through vision to learn and understand the purpose of the operation, and then gradually transfer the action into long-term memory. In this stage, learners' movements are not yet coordinated and stable, and they still do not know where their shortcomings are. Therefore, in this stage, using oral instructions and visual models can help learners recognize the main points of the action (Schmidt & Lee 1999). In PE class, the teacher's instruction, guidance, and execution of slow-motion drills are highly effective for students to cognitively understand the requirements and parameters of motor movement.

In the associative stage, the learner aims to make movement adjustments and string small movement skills together. After acquiring the basic concepts of movement in the cognitive stage, learners have understood the direction of improvement and continue to practice. This stage is also called the motor stage (Adams, 1971), because it aims to learn how to perform skills (Schmidt & Lee, 1999). After continuous practice, learners need to detect and correct errors in performance in order to perform smooth and stable movements. Therefore, learners need to transform their declarative knowledge into procedural knowledge, which means transforming what to do into how to do it. In PE class, the teacher's feedback should be more accurate and focus on the timing of the skills that the student is attempting to refine.

After continuous practice, the student can reach the autonomous stage. In this stage, the learners do not have to concentrate on skill and can perform a skill without paying attention to the action itself. They seldom consider the correctness of the action but react automatically, which means that athletic performance is largely automatic and the need for cognitive processing is small (Schmidt & Lee, 1999). Exercise during this period has entered long-term memory and players automatically adjust movement consistently and stably. There is still room for improvement, but the corresponding progress is slow. In PE class, students can still make small mistakes, and be able to find and correct them and produce their best performance.

PE curriculum only gives students a limited frequency and time for class. Therefore, the study indicates that teachers should promote physical exercise in their spare time. Pang (2010) pointed out that students' inability to obtain guidance outside of the course space and schedule are the drawbacks and challenges of traditional face-on-face PE in higher education. PE courses should clearly require students to explore opportunities for physical exercise before, during, and after school and within the community (McKenzie & Lounsbery, 2013).

2.2. Related research about using technology in physical education

Educational technology has been widely used in PE. From 2010 to 2012, educational technology, including online platforms, started draw significant research attention. Some researchers have used online learning as a platform for their studies. Huang, Chiu, Chin, Hsin, and Yu (2010) used an e-learning platform to provide sports materials and to demonstrate physical motions and exercises. The findings of their study indicated that multimedia content not only increase the efficiency of learning but also its appeal to students. Similarly, Papastergiou and Gerodimos (2013) used a web-based multimedia course to help undergraduate students acquire new knowledge about basketball. This study demonstrated that the combination of web-based multimedia courses and traditional face-to-face teaching is more effective than face-to-face teaching alone. Additionally, Zou et al. (2012) designed a Moodle course (an online learning management system) that provided videos of the world table tennis champions performing various strokes to help children learn how to play table tennis. The study demonstrated that students who participated in the Moodle course exhibited more knowledge and competence.

Since 2012, more technology products have been developed and used for educational research purposes and related studies have displayed greater research efficiency. Huang, Kuo, and Lin (2015) developed a golf-analysis system with a Wii balance board and Kinect to help detect golf-swing errors. Their study provided novice golf players with a reasonably priced and efficient golf-swing analysis system. Chen et al. (2013) also used Kinect, in combination with a computer-assisted self-training system, for yoga exercises, and developed a system capable of assisting a yoga practitioner in self-training, the performance of correct postures, and injury prevention. Aside from studies that have used the Kinect, Chen, Li, Lin, and Chang (2015) used a computer-aided system to train and improve the judgment skills of volleyball referees. Their findings showed that with the aid of their system the judgment performance of referees was improved. Yang, Li, and Xu (2017) also used a computer-aided artificial-intelligence-instruction system for basketball training in PE. The system in their study showed numerous advantages over traditional teachings, such as the liberation of human resources, reduced cost, energy conservation, and the modernization of education. Additionally, Chang, Ho, Wang, and Lin (2014) used a Wireless Inertial Measuring Unit (IMU) to measure body rotation in golf swings. The findings revealed that a wireless IMU is a feasible method for measuring body rotations. Lee et al. (2015) also used an IMU device for assessing lower limb locomotion, which demonstrated that IMU sensors exhibit potential capabilities for physical activities with different levels of intensity, such as walking, running, and jumping. Furthermore, Kitagawa and Ogihara (2016) used an IMU to develop a system for monitoring human gait. They did so by first identifying characteristics of gait, then by using a sensor attached to the dorsal of the feet of elderly individuals to measure foot trajectories. Yu, Wu, Wang, Chen and Lin (2020) also used tablets and motion-tracking sensors to help students to record their shot data and utilized the Moodle system as a reflective platform for students to review the practicing videos and rethink their performance.

The aforementioned studies in teaching and training all took time and required financial resources in the development of a new system. Therefore, some researchers have turned tablets, comparatively economical teaching tools, in their studies. Hung and Chen (2016) investigated the teaching of table tennis in PE by using tablets and discovered that combining tablets with traditional learning methods had beneficial effects on students' skill development. Moreover, our previous study (Hung et al., 2018) explored the ways in which tablets could be integrated into a badminton course to enhance the motivation and skills of learners. Furthermore, Hung et al. (2018) also indicated that the proposed WISER model – Watching, Imitating, Self-examining, Enhancing and Repeating – could be verified as an ideal pedagogical model for PE with mobile devices. In WISER model, students would watch the demonstration videos and imitate the skills. When students started to practice, the practicing process would be taken by tablets meanwhile. After practicing, students could improve themselves through reviewing the videos. They could raise the questions and discuss with the instructor about how to improve the skills. The instructor could also give proper advice to students, which could help students learn the skills effectively. Then, the students could practice and improve their skills repeatedly. The students who adopted the WISER model showed better performance in both motor-skill learning and motivation than those who were given the face-to-face approach. However, further pedagogical research is needed to examine the ways students can use video feedback technology for greater self-regulation (Hung et al., 2018). Studies indicate that student learning needs to be evaluated in a more naturalistic and authentic assessment manner (Melograno, 2000; Tolgfors, 2018). Therefore, this study searches for solutions to evaluate students' learning growth. Compared to the conventional assessment tools, a portfolio is a great tool for students to collect their learning outcomes in more authentic situations and to enhance their personalized PE experience. Therefore, this study aims to employ a friendly and familiar tool as a digital portfolio with tablets to enhance students' personalized PE learning experience and to prompt or reinforce student engagement in physical activity, sport, or fitness beyond the PE lesson.

2.3. Social media networks and education

Learning Management Systems have been widely used as a method for enabling students to engage with course learning materials. Innovative learning models are required to meet the social needs of a new generation of students. For these students, learning environments require connections to rich social environments that cannot be attained only through conventional learning management systems (McLoughlin & Lee, 2007). The rapid development of social media networks has created opportunities for innovation by allowing people to present themselves, share and receive information, and connect with one another (Manca & Ranieri, 2013; Al-Mashaqbeh, 2015).

Social media networks were initially designed for the purpose of social interaction between those who shared a campus or special-interest group. As informational and computational media, social media networks can enhance interactions between teachers and students outside of class. Currently, an increasing amount of research is focused on examining the potential of these networks in education and various pedagogical processes (Aydin, 2012; Ellison, Steinfield, & Lampe, 2007; Al-Mashaqbeh, 2015; Greenhow & Askari, 2017; Manca & Ranieri, 2016). Published literature reviews have focused mainly on the perceptions and experiences of college students (Aydin 2012; Manca & Ranieri, 2013) and higher education faculty (Forkosh-Baruch & Hershovitz 2012). Several studies have analysed data from student surveys to assess the benefits of Facebook as an educational tool. Social media tools can support student education by functioning as pedagogical tools for connectivity, social support, and information aggregation (Mazman & Usluel, 2010). Ellison et al. (2007) found that students' online social activities with Facebook help them to engage in their communities actively, especially for students with low self-esteem and low life satisfaction. Roblyer, McDaniel, Webb, Herman, and Witty (2010) reported that students were likely to be open to the potential of Facebook as a method for educational communication and mentoring. Moreover, applying the concepts of social software and Web 2.0 applications, Mcloughlin and Lee (2007) proposed 4 benefits of using social software tools as an educational method: (1) connectivity and social rapport; (2) collaborative information discovery and sharing; (3) content creation; and (4) knowledge and information aggregation and content modification. Moreover, some studies have indicated that using Facebook as the course management system is a cost-efficient and effective way to increase student involvement in discussions and out-of-class communication among instructors and students (Albayrak & Yildirim, 2015; Miron & Ravid, 2015; Raza et al., 2017). Therefore, Facebook is a social networking tool that allows groups and individuals to engage in peer-to-peer conversations.

In tandem with the aforementioned research, this study aims to combine the use of tablets and Facebook as a friendly portfolio tool in PE to assess their effects on badminton learning. Using Facebook and tablets enables this study to lower the cost, appeal to users, and save more time because no time was spent on system development.

3. Methods

3.1. Portfolio-based WISER model

The features of tablets and Facebook allowed this study to enrich the content of lectures. A Facebook Group was set up for learners to acquire the learning materials during and after class. In the meantime, to construct the learners' e-portfolios, the instructor recorded each learner's motions during class and uploaded them to their individual Facebook account through Messenger after class. Therefore, this study improved upon our previous WISER model (Hung et al., 2018) by developing the "portfolio-based WISER model," as illustrated in Figure 1. The original five-step WISER model was enhanced by portfolios to achieve a more flexible and personalized pace of PE learning. Students could obtain self-reflection from their video-based portfolios and the interaction with the instructor. Therefore, they could monitor their growth in skill learning. Before conducting the portfolio-based WISER model, the instructor illustrated the whole process in detail for students to make them clear about the process. Also, the instructor assisted students in following the model in a correct way so they could practice.

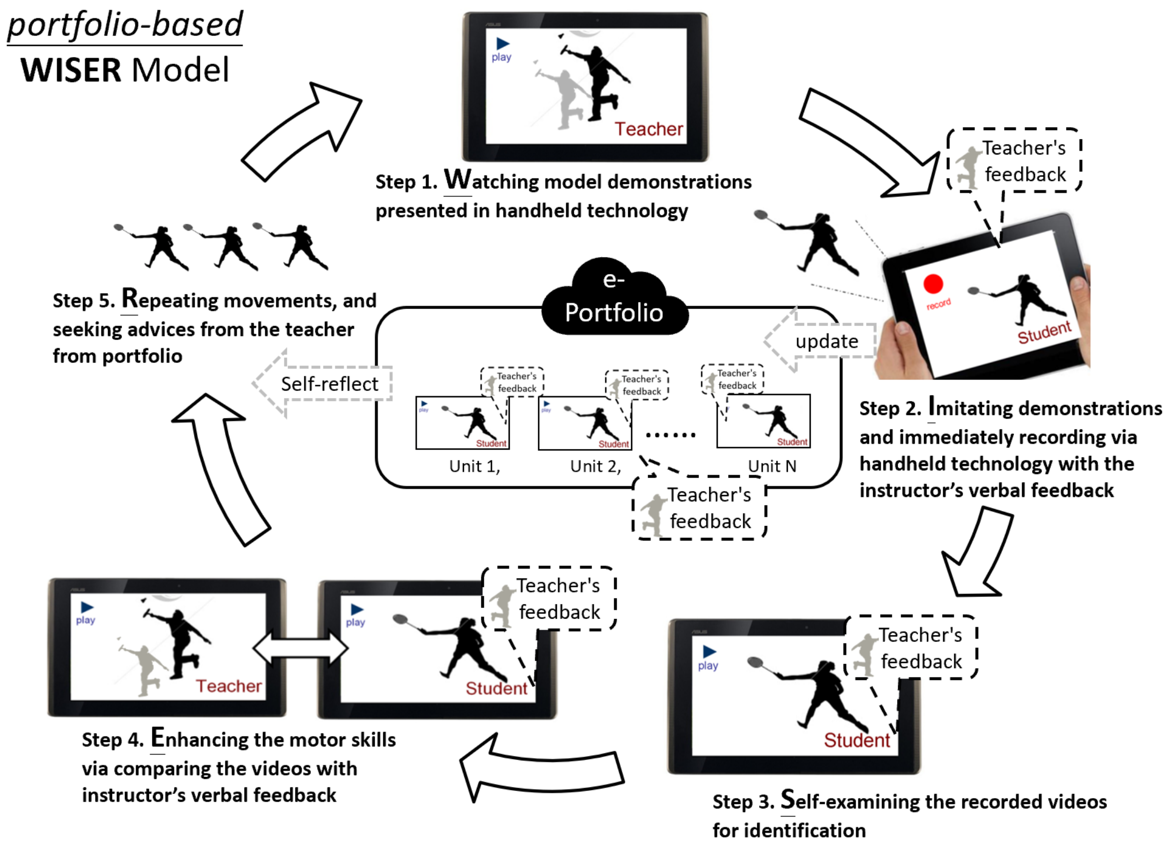

Figure 1. Portfolio-based WISER model for PE learning

Step 1. Watching model demonstrations presented with handheld technology: The students needed to watch the digital videos of different basic skills, which were demonstrated by the teacher via tablets. The students could go forwards and backwards, and replay the videos.

Step 2. Imitating demonstrations and immediately recording via handheld technology with the instructor's verbal feedback: The students needed to imitate the same movements according to the videos they just watched. At the same time, the students were divided into groups, and their practice processes were recorded by the instructor along with the instructor's verbal feedback via the recording function of the tablets. The instructor gave corresponding feedback based on the different performances of each student following the skill grading criterion (see Table 1).

Step 3. Self-examining the recorded videos for identification: After recording the practice videos on the tablets, the students could watch them instantly on the screen of their tablets. These videos enabled students to identify the flaws of their own movements according to the teacher's verbal feedback.

Step 4. Enhancing motor skills by comparing the videos with the instructor's verbal feedback: The students needed to compare the practice videos and teacher's demonstration videos to further reflect on the differences between them so that they could follow and refer to the teacher's verbal feedback in the video as a supplementary reference.

Step 5. Repeating movements and seeking advice from the teacher through portfolio: After understanding the differences between the practice videos and the teacher's demonstration, the students could practice their movements repeatedly and then seek further advice from the teacher face-to-face. In the portfolio-based WISER model, the teacher can give comprehensive feedback to students by referring to the students' portfolios from different weeks.

3.2. Participants

This study divided the research participants into the experimental group (with the portfolio-based WISER model) and the control group (with traditional teaching methods). The lecturing content of both groups was identical. The number of the participants was 199 in total, who were students from six badminton classes at the university where the researcher is affiliated. The researcher assigned three classes as the control group and three classes as the experimental group before the experiment started. Each class was grouped into four groups on a random basis, and each group included 8 to 9 students. Participants were grouped according to the university's course information system; three classes formed the control group in one semester (Class 1 = 30; Class 2 = 36; Class 3 = 36; *N* = 102), and the other three classes formed the experimental group in the next semester (Class 1 = 29; Class 2 = 33; Class 3 = 35; *N* = 97), for a total experimental period of one year. During the experiment, some learners failed to complete the smashing or footwork tests, and some withdrew from the class.

3.3. Experimental procedures

The experiment was based on a quasi-experimental non-equivalent pretest/posttest control/comparison group design. In the beginning, this study uploaded pre-recorded teaching materials of smashing and footwork skills demonstrated by professional Taiwanese badminton players onto a tablet and Facebook. Next, students in the control group were taught using traditional teaching methods and students in the experimental group were taught using tablets and Facebook. Before and after this step, participants took a pretest and a posttest. The timeframe of this experiment consisted of two semesters, each including one week of pretesting, eight weeks of lectures, and one week of posttesting. The same instructor led both experiment group and control group in both semesters. Figure 2 shows the experimental procedure.

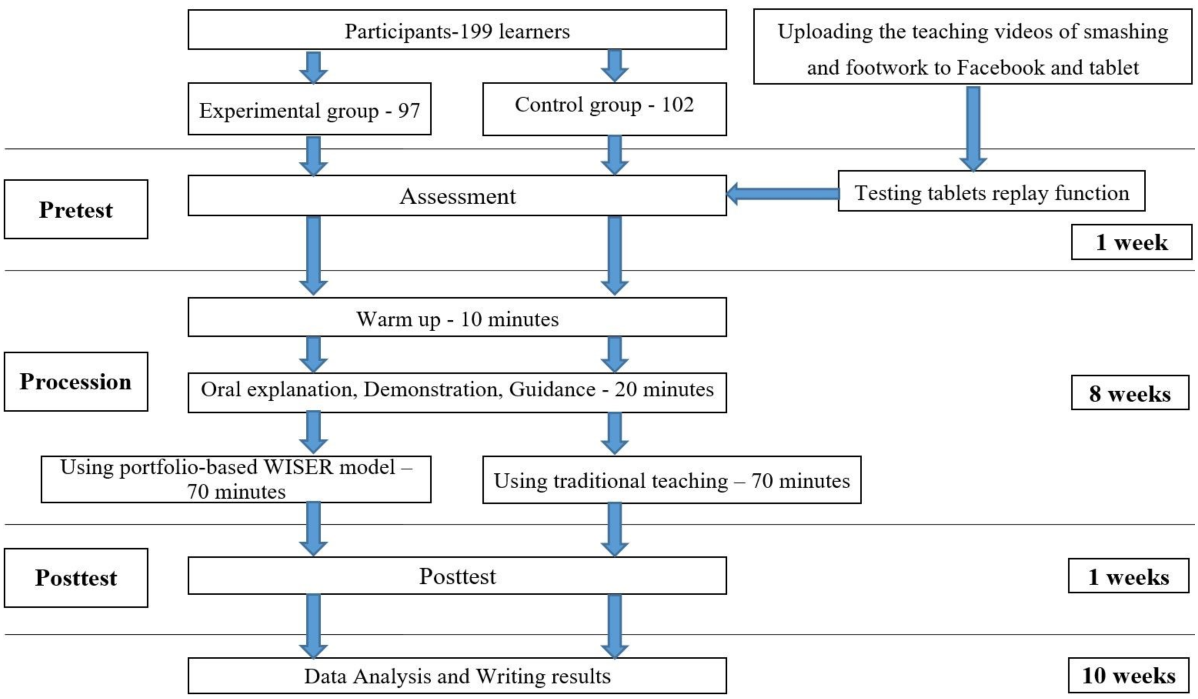

Figure 2. Experimental procedure

3.3.1. Procession step: Control group

The control group was given a 100-minute lesson for eight consecutive weeks during the semester. These lessons included a 10-minute warm-up, 20-minute lecture, and 70-minute group practice. During the 20-minute lecture, the instructor verbally explained and physically demonstrated smashing and footwork skills. For the next 70 minutes, the instructor provided each learner with one-on-one verbal and demonstrative feedback and guidance until the class was finished. The instructor rotated to each group to observe every learner's learning process and offered the comprehensive feedback through verbal and physical demonstration one on one.

3.3.2. Procession step: Experimental group

The experimental group was also given 100-minute lessons for eight consecutive weeks during the semester; these lessons included a 10-minute warm-up, 20-minute lecture, and 70-minute group practice. The lecture was executed using tablets and Facebook content that had been uploaded at the beginning of the semester. The primary purpose for the teaching strategy was to provide students with a model demonstration videos that could be used to compare with their personal practice videos on the Facebook Group.

During the 70-minute group practice, the teacher adopted the portfolio-based WISER model to instruct students. Each group containing 8 to 9 students was assigned to one tablet. The teacher rotated to each group to provide the comprehensive feedback regarding the movements during each student's practice process, and both comprehensive feedback of the teacher and the practice process of the student were video-recorded simultaneously as a practice video. After the teacher finished providing the feedback, the students could watch the practice video to receive the comprehensive feedback for the second time with the replay function of tablets, or raise some problems from videos to the instructor personally.

After the seventy-minute practice time, the practice videos were uploaded to each student's Messenger account. The students could watch the practice video for after-class review and compare it with the model demonstration videos on the Facebook Group (as shown in Figure 3). This process enabled students to receive comprehensive feedback for the third time. Also, should the students have any concerns regarding the movements, they could discuss with the teacher with Messenger, which could enhance the interaction between the teacher and students. The e-portfolio was created for students to record their entire learning progress on their personal Messenger account (as shown in Figure 4).

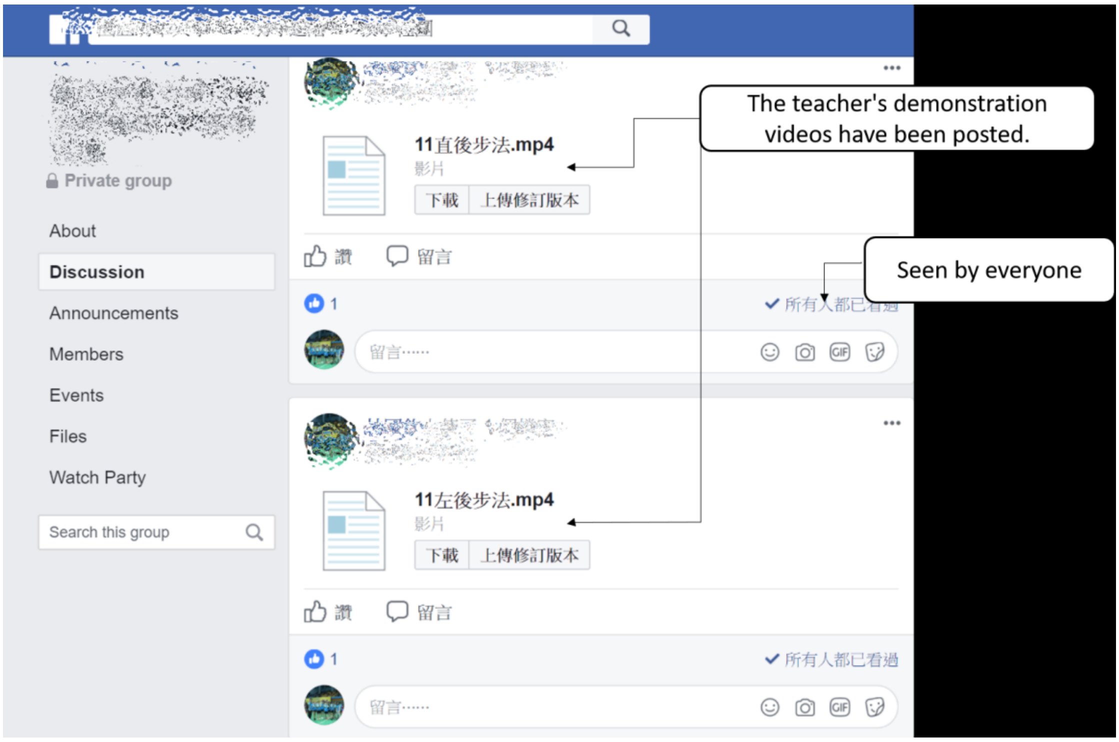

Figure 3. Facebook Group for badminton skill learning

Throughout the eight-week experiment, participants in the experimental group could use tablets to make movement adjustments via real-time visual feedback and use the e-portfolio for after-class-reviewing via Facebook Messenger. Figure 3 and Figure 4 present the Facebook teaching group and the student's e-portfolio, respectively. This study applies Facebook Group and Facebook Messenger for students' badminton learning. In the Facebook Group, the teacher uploaded the model demonstration videos. Therefore, students could also review the teacher's model demonstration before and after class. In the Facebook Messenger, the student received his/her weekly practice videos after class (Figure 4). Therefore, students have video-based portfolio made with their weekly videos. Moreover, after students watched their practice video, students can seek further personal guidance from the teacher according to the practice video. In the portfolio-based WISER model proposed in this study, we apply Facebook to facilitate the relationship not only from instructor to learners but also from learners to instructor. Therefore, beyond one-way teaching, this study uses Facebook as a social networking tool from two-way teaching.

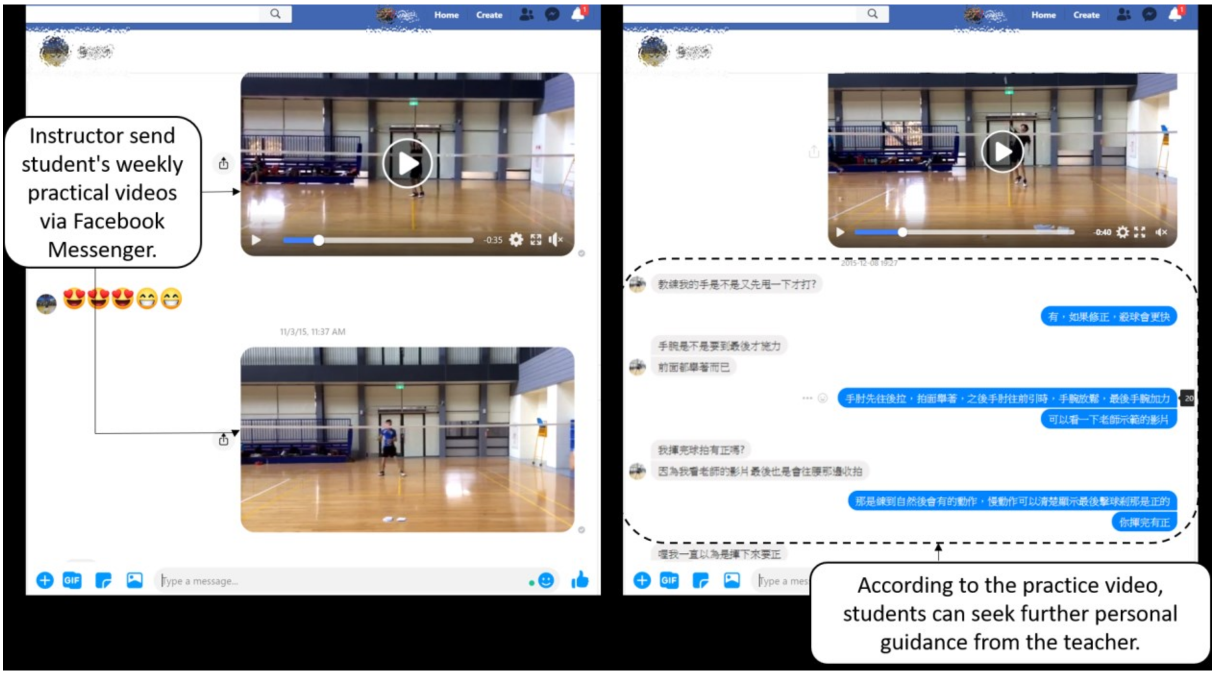

Figure 4. Learner's e-portfolio

3.4. Instruments

Three research instruments were used in this study. The first was a smashing learning test adapted from badminton skill test (Lin, Hung, & Young, 2014), the "high clear learning test grading criteria"; this included seven criterions for grading, as displayed in Table 1. The second instrument was a footwork-learning test with nine criterions. The criteria used in the smashing and footwork-learning test (as shown in Table 1) were determined by three professors certified as A-rank players and national coaches by the Chinese Taipei Badminton Association (CTBA). Therefore, these two tests have high content validity. When a learner's one movement matched one of the criterions, he or she would get one score for the test.

Table 1. Grading criterions of the smashing and footwork-learning test

Skill	Smashing	Footwork
Grading criterions	• The elevation of both elbows	• Forehand backcourt front cross footwork
	• The balance of both arms	• Backhand backcourt back cross footwork
	• 90 degree turn to the right/left side	• Backcourt straight back cross footwork
	• The rotation of the shoulders	• Forward forehand back cross footwork
	• The snap of the wrist	• Forward backhand front cross footwork
	• The follow-through of the shoulders	• Frontcourt straight front cross footwork
	• The fluency of movements	• Forehand side footwork
		• Backhand side footwork
		• The fluency of movements

To determine reliability, the researcher and one CTBA player assigned grades according to the smashing and footwork criteria. Kendall's coefficient of concordance was also used to determine the reliability of the two tests. The pretest and posttest scores for smashing and footwork obtained using Kendall's coefficient of concordance were .89, .84, .93, and .93, respectively.

3.5. Data analysis

Three data sets were used for the data analysis badminton skills learning. To make sure that the students were assigned to each group without any preference, an independent sample *t* test was utilized to gauge if there was a significant difference between the pretests of both groups. Second, in order to understand different progress levels of both skills in each group, a paired sample *t* test was deployed to calculate whether the posttests were significantly better than the pretests. Third, if the posttests were significantly better than the pretests, an analysis of covariance (ANCOVA) was be conducted to determine whether a significant difference existed between the experimental group and control group. A homogeneity test was also conducted (where the scores of the pretest were the covariate and the scores of the posttests were the dependent variable) to determine similarities between the two groups. The significance level for all statistical analysis was $\alpha = .05$.

4. Results

An independent *t* test was first conducted in the present study for the purpose of knowing whether learners were assigned without any preference for each group. The result was that there was no significant difference in the pretest scores between the two groups (*p*-value = .13 for smashing and *p*-value = .33 for footwork). The learning outcomes of smashing and footwork in each group are be discussed individually below.

4.1. Badminton skills learning outcomes of EG and CG

Table 2 summarizes the results of the paired sample *t* test of the pretest and posttests scores in the experimental group and control group. It was found there was a significant difference between the pretest and posttests scores in both EG and CG, and the posttests scores were higher than the pretest scores in both groups. This means that the learners improved their skills after they were taught with either teaching method for badminton skills.

Table 2. Summary of the paired sample t test of the pretest and posttest scores in each group

Testing skills	Group	Testing time	Mean	*SD*	*n*	*t*	*p*
Smashing	Control	Pretest	3.76	.99	99	14.41	$< .000^{***}$
		Posttest	5.27	.96	99		
	Experimental	Pretest	3.49	1.41	97	16.24	$< .000^{***}$
		Posttest	5.43	1.02	97		
Footwork	Control	Pretest	2.51	2.19	102	14.84	$< .000^{***}$
		Posttest	5.64	1.88	102		
	Experimental	Pretest	2.83	2.38	95	21.40	$< .000^{***}$
		Posttest	7.80	.70	95		

Note. $^{***}p < .001$.

4.2. Smashing

Before conducting an ANCOVA, we first tested for any difference in pretest scores between the experimental and control groups. For the smashing test, the results of the test for homogeneity in smashing skills demonstrated that the interaction between covariates (pretest scores) and dependent variables (posttest scores) had no significance, with the *p*-value = .96. This indicated that no significant difference existed on the slopes of regression of the pretest against posttest scores between the two groups; hence, ANCOVA could be conducted.

After conducting the homogeneity test for each group to exclude the effects of pretest scores on posttest results, ANCOVA analysis could be carried out. The results indicated that there was a significant difference between the posttest scores of the experimental group and the control group, with *p*-value = .032 (Table 3). Additionally, average scores after adjustments were 5.48 for the teaching method involving tablets and Facebook and 5.22 for the traditional teaching method. These results indicated that using the teaching method involving tablets and Facebook led to more significant improvements in smashing skills than using the traditional teaching method. In Figure 5, the blue and red lines are the fitted lines of the relationship between pretest and posttest scores for the experimental and control groups, respectively. It was found that both fitted lines are almost parallel, where the homogeneity of the slopes for both groups existed. In addition, the average posttest scores of the experimental group were higher than those of the control group.

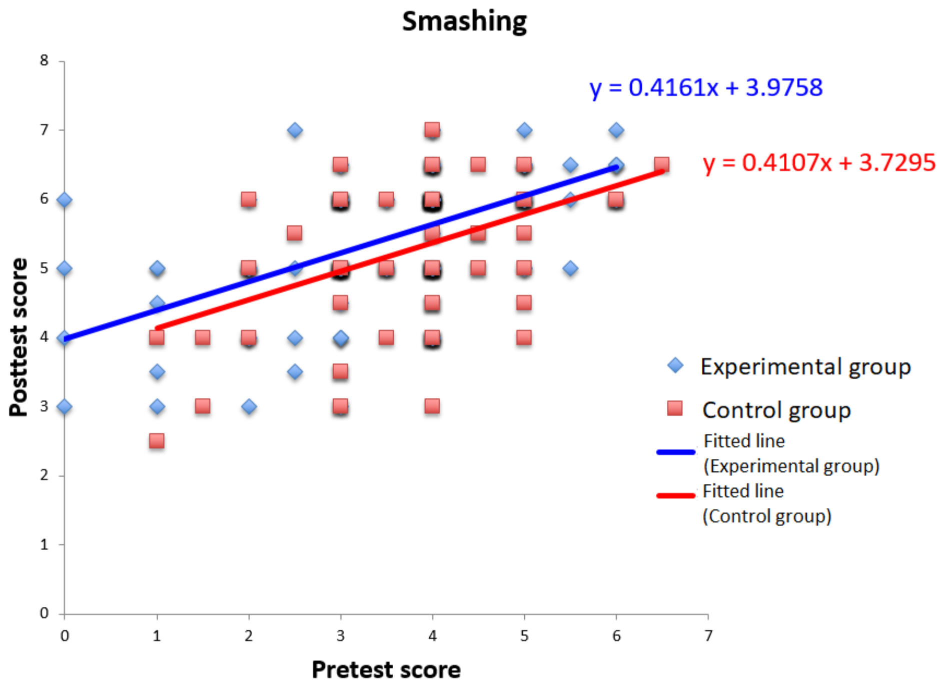

Figure 5. The relationship between the pretest and posttest scores of the two teaching groups

Table 3. ANCOVA table of smashing tests

Source	Sum of squares	Degrees of freedom	Mean square	*F*	*Sig.*	Partial Eta squared
Pretest scores (smashing)	49.29	1	49.29	67.31	.000	.259
Group	3.43	1	3.43	4.68	.032*	.024
Error	103.83	106	0.98			

Note. $^{*}p$ <.05.

4.3. Footwork

For the footwork test, the results of the homogeneity test for footwork demonstrated that the interaction between covariates (pretest scores) and dependent variables (posttest scores) was significant, with $p < .001$, indicating a difference in the slopes of the pretest scores against the postest scores between the experimental and control groups. From Figure 6, the non-homogeneity was shown by the blue and red lines which were the fitted lines of the relationship between pretest and posttest scores for the experimental and control groups, respectively. Unlike Figure 5, the two fitted lines are not parallel so that the assumption of homogeneity of the slopes for both groups failed when conducting an ANCOVA. Because the assumption of homogeneity was not satisfied, ANCOVA could not be conducted. Instead, the Johnson-Neyman method was used to adjust the results. The Johnson-Neyman technique provides additional information by establishing regions of insignificance for group difference at a specific point on the covariate (Johnson & Neyman, 1936; D'Alonzo, 2004).

According to the procedure of D'Alonzo (2004) and Johnson (2016), the insignificance difference of two groups was found at the pretest scores occurring in the range of 5.09 and 7.66. That is, when the pretest score is higher than 7.66 and lower than 5.09, a significant difference exists between the two groups in the posttest. In Figure 6, when learners' pretest scores were higher than 7.66, the experimental group's posttest scores were significantly higher than those of the control group. When learners' pretest scores were lower than 5.09, the experimental group's posttest scores were significantly higher than those of the control group. When learners' pretest scores were between 5.09 and 7.66, no significant difference was evident between the posttest scores of the two groups.

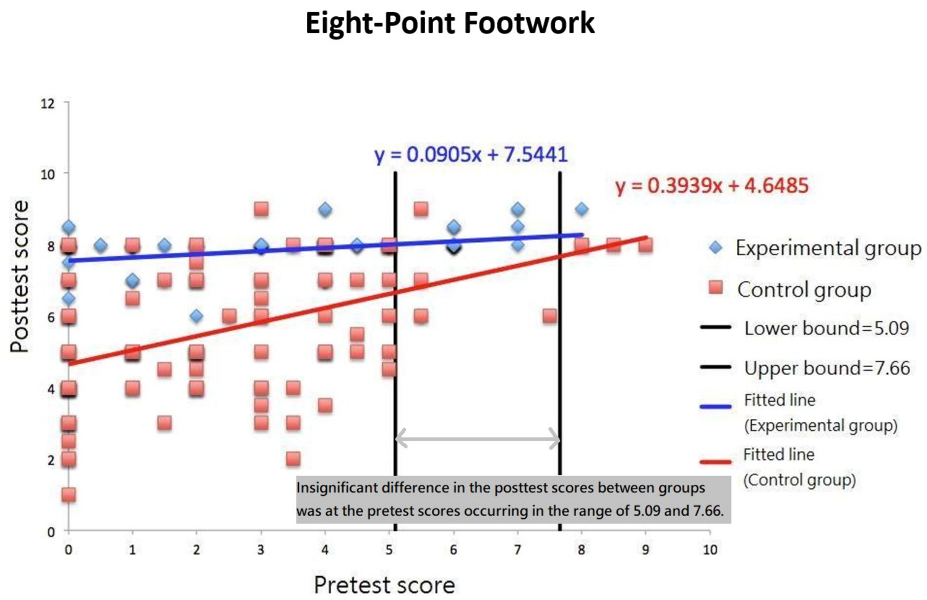

Figure 6. The results after employing the Johnson-Neyman method

5. Discussion

In traditional teaching without any recording devices, the learner is unable to see his/her mistakes because there is no recording of their performance available during class, and they must therefore rely on their memory alone outside of class. In this study, with the use of tablets, the performance of the student and the instructor's instant feedback were recorded as a performance video. This teaching method can be differentiated from past studies using tablets that recorded only the performance of students (Hung & Chen, 2016; Hung et al., 2018; Yu et al., 2020).

Furthermore, to create an e-portfolio, the present study uploaded the performance videos onto Facebook Messenger in each student's account. A student could review his/her performance videos regularly after class. If students had any confusion about the smashing or footwork skills, they could discuss questions with the instructor on Facebook Messenger through video or text (as shown in Figure 7). This teaching method increased the interaction, and helped students keep track of their learning progress each week and avoid making the same mistakes. The proposed method makes instruction more diverse and flexible. Students learn the main points of skills efficiently and deeply in advance. Also, e-portfolios are highly portable and easy operation. This study contributed empirical evidence to support past research utilizing Facebook as a course management system to increase student communication and involvement between the instructor and students in and out of class (Albayrak & Yildirim, 2015; Raza et al., 2017). In particular, students who have low self-esteem and satisfaction with life are more likely to communicate with the instructor after PE class (Ellison et al., 2007). Moreover, the results demonstrated that social networks can be an incredibly useful instructional tools because instructors and learners can share information and engage in discussion with one another through Messenger. Teaching methods that utilise social networks, when compared with traditional teaching methods, result in greater connectivity between instructors and learners (Al-Mashaqbeh, 2015; Manca & Ranieri, 2013; Mazman & Usluel, 2010).

For both the EG or CG, for smashing or footwork, with or without the portfolio-based WISER model, the posttest scores were all significantly better than the pretest scores, indicating students in the CG could still progress with only the adoption of the traditional teaching method. Additionally, with the aid of the portfolio-based WISER model, the smashing posttest scores of the EG were all significantly better than those of CG. However, the footwork posttests of the EG were significantly better than those of the CG only when the pretest scores were lower than 5.09 or higher than 7.66.

Furthermore, the present study explored the key points of smashing and footwork learning and investigated how the portfolio-based WISER model contributed to helping students with learning of both of these badminton skills. Smashing learning requires the understanding of the fluency and coordination of the shoulder, elbow, and wrist. In particular, the students need to know how to correctly use the strength from the shoulder, elbow, and wrist in sequential order when performing smashing to avoid injuries. On the other hand, compared to smashing learning, footwork learning only relies on the explicit instructions related to stepping with the left or right foot and jumping or not jumping in sequential order to alternate positions.

Due to the complexity of movements, this study designed a portfolio-based WISER model for use during and after classes. This model helped students learned the skills. During the 100-minute classes, students in the EG practiced the skills and the instructor provided instant feedback at the same time. In addition, students could review the practicing videos a second time after practicing. Then, the instructor and students could discuss the problems on Messenger to have more interaction in the instruction. In addition, based on the portfolio-based WISER model, the after-class reflection is also another important strategy to make promote skill learning. The idea is similar to developing an e-portfolio learning environment to support pre-service teachers' reflection of learning (Roberts, Maor & Herrington, 2016). As shown in Figure 7, the first and the second student confirmed their learning conditions through their extra practice videos.

The first student took a video of herself practicing and sent it to the instructor through Messenger to discuss the problems she saw. She mentioned that *"I could still see that the elbow was in the wrong position which was too low, and then I raised the elbow back up before hitting the shuttle."* Furthermore, she also raised two questions about the movements. *"Did I stretch my shoulder so much in the backswing that all the sub-motions were influenced?" "Is it possible to lose extra power or cause a sports injury when stretching the shoulder too much in the backswing?"* This example shows us the portfolio-based WISER model can supplement the after-class interaction, which could not be achieved through the WISER model in the past. The interactive approach was vivid and helpful, allowing the instructor to check if the movements were correct or not immediately and tell students whether or not incorrect movements could cause injuries to the body in advance.

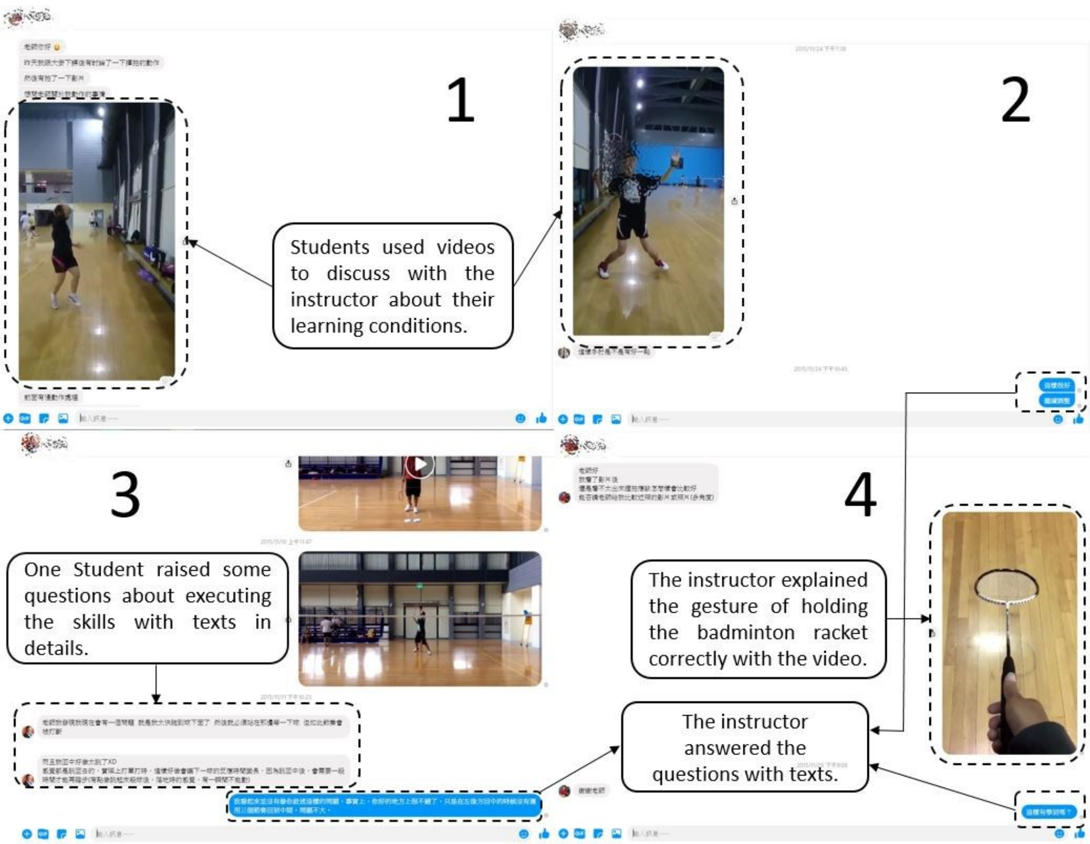

Figure 7. Interaction between the instructor and students on Messenger

From the weekly portfolio videos on Messenger, the instructor noticed the second student's (Figure 7) body and arms were overstretched in class. After watching the practice video, the student reflected on the instruction in detail. The student recorded an improved practice video and sent it to the instructor through Messenger. He asked the instructor, "*Did the swing of elbow improve?*" to confirm the correction of movements in advance. The instructor also provided positive feedback. In another example, the third student raised questions about executing the skills via texts. The student understood the importance of footwork and asked the instructor some questions after watching the videos on Messenger after class. He mentioned that "*I thought that I ran so fast that I reached below the shuttle too early. I had to stand there to wait for the shuttle, and the tempo was interrupted.*" He also said that, "*I found I jumped so much that I almost jumped back to the court centre and the hitting tempo felt wrong.*"

The above questions show that students raised these questions after reviewing the videos, which allowed students to reflect on how to apply the learning from class to practical game playing. In addition, the instructor also replied to students' questions with videos to make the explanations more vivid and concrete. The results from the experiment show that the proposed method made instruction diverse, flexible and interactive. Students learned the main points of skills efficiently and deeply in advance.

To further discuss how this study applied the portfolio-based WISER model in PE learning, Figure 8 shows the pedagogies and learning process. In the traditional class-based PE learning process, the pedagogy is an instructor-centered approach. In the portfolio-based WISER PE learning process, which is a learner-centered approach, convenient e-portfolios were established to provide more chances for students to reflect on the learning process and enhance the frequency of interaction between the students and instructor. This kind of pedagogy brings new chances and contributions to PE teaching.

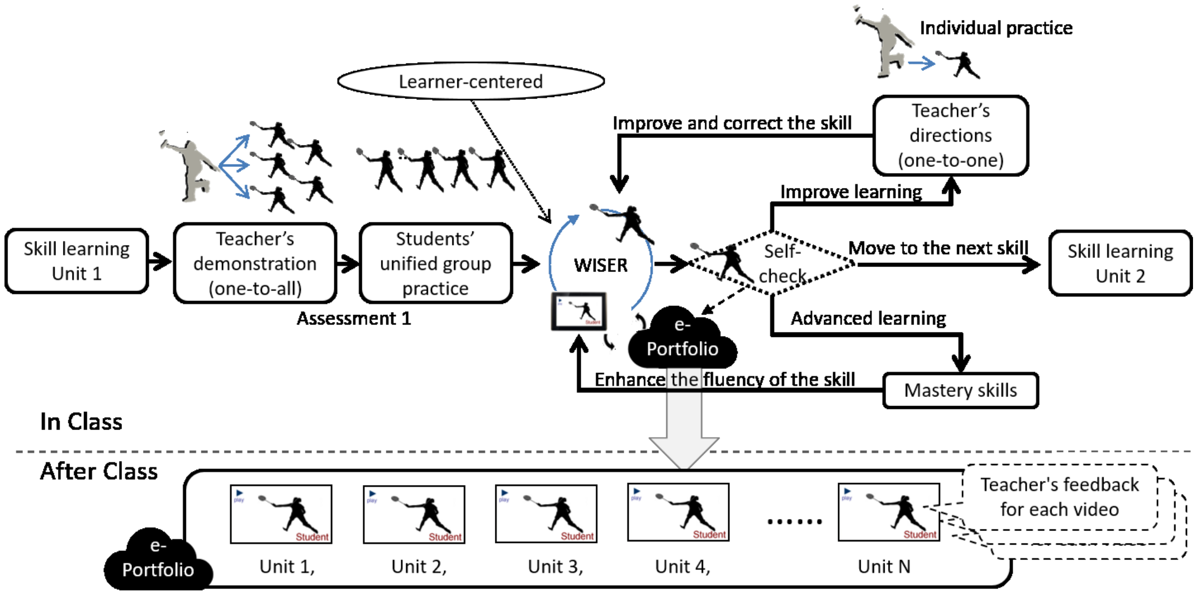

Figure 8. The pedagogies of portfolio-based WISER model in PE class

Fitts and Posner's (1967) stages of learning on motor skills acquisition have a long history in traditional PE. However, research (Davids, Bennett, & Button, 2008) also addresses a challenge of traditional PE, in that students only have a limited amount of time to learn with the teacher. However, to achieve a high level of expertise, students need to spend a lot of time on conscious practice. At the same time, the instructor has to monitor the individual progress of the students at different levels over time. Therefore, to deal with these challenges, this study further discusses how the proposed pedagogies of the portfolio-based WISER model could be exploited in each step of the motor skills acquisition process (Table 4).

In the cognitive stage, students need to understand what to do, therefore, the teacher needs to perform the correct demonstration in front of students (Assessment 1 in Figure 8). In this stage, the development of skill begins with clear instructions for practice. However, it might be challenging for students to comprehend instructions in the limited time during class (Kee, 2019). Therefore, students need to follow Step 1 of the portfolio-based WISER model to watch model demonstration videos with tablets. In this step, students can acquire visual and verbal knowledge and pay attention to the sequence and how to perform the motor movement correctly. Students need to imitate the same actions based on the video and pay attention repetitively to the object of focus.

In the associative stage, students aim to translate declarative knowledge into procedural knowledge to perform the skill after students understand the instructions in the cognitive stage. Timely feedback gives important support during the learning process. Moreover, it is helpful to receive verbal feedback from the teacher to ensure that students are practicing according to instructions (Kee, 2019). Therefore, they need to follow steps 2 to 4 of the portfolio-based WISER model. They need to imitate the same movement according to the videos they just watched. After recording the practice videos on the tablets, students can watch them instantly on the screen of their tablets. Moreover, students need to compare the practice videos with the teacher's demonstration video to further reflect on the differences. Therefore, students practice their movements repeatedly according to the teacher's oral feedback to find out the defects of their movements. After that, students should be familiar with the basic instructions of the practice.

In the autonomous stage, students try to automate their performance. In this stage, it is difficult to make major breakthroughs based on student performance. Students have internalized the skills automatically. Some practical suggestions for guiding students' skills development according to the individual characteristics are needed (Kee, 2019). Therefore, students need to follow Step 5 of the portfolio-based WISER model. Students can practice the movements repeatedly, and they can also seek further individualized advice from the teacher through Messenger. In addition, in order to gradually improve and continue to see students' progress, students need to refer to the personal portfolios. After extensive practice, students are expected to perform this skill automatically without paying attention and clear instructions.

Table 4. The portfolio-based WISER model facilitates motor skill learning in the following motor acquisition stages

Stage	Purpose	The related pedagogy design
Cognitive (Verbal-motor stage)	What to do (Gathering information)	• Teacher's demonstration • Step 1. Watching model demonstrations presented with handheld technology
Associative (Motor stage)	From what to do to how to do (Putting actions together)	• Step 2. Imitating demonstrations and immediately recording practice via handheld technology with the instructor's verbal feedback • Step 3. Self-examining the recorded videos for identification • Step 4. Enhancing motor skills by comparing the videos with the instructor's verbal feedback
Autonomous (Automatic stage)	Think minimally and react automatically (Extensive practice)	• Step 5. Repeating movements, and seeking advice from the teacher from the portfolio • Referring to their personal portfolios and seeking individualized advice after class

6. Conclusions

This study utilized the portfolio-based WISER model to help students reinforce their understanding of badminton skills, and the results indicated that using technology as a teaching tool is beneficial to badminton learning in PE. The key benefits of employing the portfolio-based WISER model in PE courses are described as follows:

(1) Movement adjustment via instantaneous recording and feedback:

The recording function of tablets enabled the instructor to instantly record and simultaneously provide verbal feedback to the learners. With the recordings, students were able to constantly adjust and improve their own movements by reviewing the videos.

(2) Connectivity and information sharing:

This study used Facebook Messenger to create an e-portfolio for each learner. Because learners were already actively using Facebook and were therefore comfortable operating the technology, it was relatively easy to make badminton learning in a social media setting a part of their routine. With a closed group on Facebook, the instructor and learners could easily share learning materials such as videos, references, links, and resources with other group members. In addition, all group members, including learners and the instructor, could create, organize, and share content with one another.

In this study, we applied tablets and Facebook to PE teaching and found that tablets and Facebook can transform the relationship between the instructor and learners from one-way teaching to two-way learning with more flexibility. However, if numerous learners are present in one class, some may be left behind. Therefore, future research should consider developing an automatic feedback system to assist the instructor. This would increase the frequency of feedback and enhance learning efficiency.

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