The Effects of Mobile App Technology on Technique and Game Performance in Physical Education

by

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A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Approved June 2020 by the
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August 2020

ABSTRACT

Informed by Behavioral Ecological Model (BEM), Technological Pedagogical Content Knowledge (TPACK) framework, and Model for Learning With Digital Video, this project assessed: (a) the effects of mobile application (App) technology on students' skill and game play development during a badminton sport education season and (b) a physical education teacher and students' perceptions about the use of the App technology. Two eighth grade classes participated in the study (the teacher only used the App in Class A; students used the App in Class B). The Poole forehand overhead clear shot skill test, game performance assessment instrument (GPAI), and opportunity to respond (OTR) observation tool were used to measure skill development and game improvement in the first study. Students' practices and game play performance were recorded. Critical incident sheets, the teacher's daily reflections, and interviews with the teacher were used in second study. In the first study, students in both intervention classes, regardless of the App use condition (i.e., teacher vs students), improved in the clear shot skill, tactical dimensions of their game performance (i.e., skill execution, decision-making, and base position), and opportunities to respond rates (i.e., success and acceptability). In the second study, there was evidence that a physical education teacher can effectively integrate the use of a motion analysis App and complement his instructional skills during regular instruction in a middle school badminton context. Also, it was evident that the App provided students with active learning opportunities through instant feedback on skill and game performance. Further research on the use of such App technologies should focus on: (a) how the App technology can be innovative to foster student learning in game play in Physical Education settings and (b) how teachers understand the use of technology along with their pedagogical skills.

Keywords: physical education, digital technology, mobile application, skill development, game performance, perceptions, badminton

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CHAPTER 1

INTRODUCTION

Technology in physical education has potential to provide teachers with a variety of teaching avenues, help students learn the skills and knowledge towards physical activity that they need throughout their lifetime (Palao, Hastie, Cruz, & Ortega, 2015). The advance of digital technology, especially mobile devices such as digital camera, smartphones, laptops, and tablet computers has opened different ways for individuals to communicate, collaborate, and produce new constructs (Groff, Klopfer, Osterweil, & Haas, 2009). Today's adolescents are fully accepting these types of technology to integrate them into various aspects of their daily lives (Green & Hannon, 2007; Rosenthal & Eliason, 2015). Accordingly, the scope of using technology in education has been changing in physical education and schools. Teachers are trying to keep track of the increasing demands of technology innovations (Krause, Franks, & Lynch, 2017). Krause et al. (2017) reported technology as one of the most frequently mentioned topics where teachers are requesting more information on it from the online forum, the Society of Health and Physical Educators (SHAPE America) Exchange (now the website has been updated to 'myshapeamerac.org'). The types of technology may include pedometers/accelerometers, heart rate monitors, Exergames/Active video games (AVG), and portable digital technologies such as smartphones and tablets that include mobile applications (Apps) (Krause & Sanchez, 2014). However, even though numerous educational technology resources have been available in physical education, many professionals are still unsure on how to use and implement the resources to reach students' needs and improve their ultimate learning outcomes as well as how to tie technological outcomes to the national standards (Krause et al., 2017).

Learning Outcomes with Technology in Physical Education

Yu, Kulinna, and Lorenz (2018) introduced the use of technologies in physical education classes. They emphasized the importance of creating technology-infused learning experiences, as students seek to achieve the developmentally appropriate learning outcomes. The National Standards and grade-level outcomes for K-12 Physical Education from the SHAPE America states that students develop physical literacy through: (a) developing competency in motor skills and movement patterns, (b) knowledge of concepts, principles, strategies, and tactics, (c) enhancing and managing their physical activity and fitness, (d) exhibiting responsible behavior, and (e) recognizing the value of physical activity for health, enjoyment, challenge, self-expression and/or social interaction (SHAPE America, 2014). Specifically, the grade-level outcomes under SHAPE America National Standards 3 specify that students use technology as a tool to help their physical activity (S3.M4.6, S3.H2.L2) and to self-monitor their fitness frequency/intensity (S3.M8.8, S3.H10.L2). For developing motor skills and sport performances, it is important to note that student will also be able to achieve those outcomes by infusing technologies into Physical Education based on the National Physical Education Standards, even though no mention is made in standards 1 or 2, regarding the infusion of technology.

The emergence of digital technology in physical education

There is evidence that through technology students can process information (Ophir, Nass, & Wagner, 2009; Rideout, Foehr, & Roberts, 2010). Pedometers and accelerometers were the initial technologies that physical education teachers could implement to measure students’ physical activity levels. Heart rate monitors were used as a tracking instrument for examining students’ activity intensity. These activity trackers are now becoming digitized.

Video technology has been used in both physical education teacher education programs and K-12 school settings. Video technology can also potentially foster / support learning in the psychomotor learning domain, skill acquisition and motor skill development (Palao et al., 2015). Video technology could be an effective tool for complementing teachers’ prompting and feedback. Computer technology has been used since 1980s to collect and analyze systematic observation data for research (Carlson & McKenzie, 1984). More recently, social media (e.g., twitter, blogs, Facebook, YouTube, and Zoom) has provided people with virtual spaces to share online resources and interact with each other. Mobile applications using smartphones and tablets were released in 2008, having various potential ways for effective teaching and learning. Krause et al. (2017) reported that most commonly discussed technology from the online forum were activity monitors (e.g., pedometers, accelerometers, and heart rate monitors), mobile devices, and social media.

Skill Execution with Video Technology in Physical Education

Digital video has been used in Physical Education as one of ways to provide feedback opportunities to support student learning, especially students’ skill execution. Video feedback has been shown to be effective in skills such as the ball toss (Janelle et al., 1997), swimming strokes (Hazen et al., 1990), and track & field sports performance (Palao et al., 2015). Furthermore, providing a self-regulating environment, as might be present in a self-assessment process, can enhance the effectiveness of this video feedback, by providing students with chance to analyze their own skill performances and helping improve peers' performance. Schwartz and Hartman (2007) designed a model for learning with digital video. They introduced the four major learning outcome that can be achieved from digital video: (a) engaging, (b) seeing, (c) doing, and (d) saying. Students *engage* in learning with video once they feel interested and the learning process is contextualized. As students *see* things that are new or familiar but demonstrated in other way in learning with videos, not only their behaviors (skills and game performances) by *doing* will be affected by videos but also they will be able to say what they discovered. In terms of *doing*, video technology is suitable on students' skill development (Janelle et al., 1997; Palao et al., 2015).

Technological Pedagogical Content Knowledge (TPACK)

The framework of Technological Pedagogical Content Knowledge (TPACK) outlines how content and pedagogy would form the foundation for effective infusion of technology into teaching practices. TPACK has become a prevalent framework to study teachers' technology integration in pedagogical use (Koehler & Mishra, 2009). This framework has three interdependent components of physical education teachers' knowledge: (a) content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). The body of knowledge will be made by combining the three interdependent knowledge in various ways and the components should be overlapping and interact within the educational contexts for teachers to implement successful teaching with appropriate use of technologies.

As an important dimension of the TPACK, if teachers want to focus on students' responsibility for their learning using technology, they would need to enable students to use a variety of portable digital devices, to discuss, discover, and deliver content knowledge during/beyond their classroom and school hours (Krause & Sanchez, 2014; Means & Olson, 1995; Yu, Kulinna, & Lorenz, 2018).

Research questions

Informed by the behavioral ecological model (Hovell, Wahlgren, & Adams, 2009), the purpose of the first study is to determine the effects of mobile application technology on students' skill and game play development during a badminton sport education season. The research hypothesis was that the use of motion analysis mobile application would improve students' badminton technique (skill) and game performance during the intervention conditions.

Informed by the model for learning with digital video (Schwartz & Hartman, 2007) and the TPACK model (Koehler & Mishra, 2009), the purpose of second project is to determine stakeholders' perceptions (a teacher and students) of the skill analysis technology used in physical education classes via interviews and document analysis. The research hypothesis is that the physical education teacher and students would have positive perceptions of using mobile application technology in their class.

CHAPTER 2

LITERATURE REVIEW

Technology Research Trend Over the Decades

Technology has become a helpful tool for students to build knowledge and get tasks done in schools. As the importance of technology in education has increased, teachers are also recognizing that student learning can be enhanced by instructional technology through special assistance for visual learners, facilitating specialized and individualized student development, and assessing students effectively (Woods, Goc Karp, Miao, & Perlman, 2008). Training of in-service and pre-service teachers is needed through professional development and Physical Education Teacher Education (PETE) programs on effective and appropriate use of technology. Thus, in order to provide teachers with good resources and to help them learn about appropriate uses of technology in the future, it is important to examine previous research findings regarding the types of technologies and how the technologies have been used in Physical Education.

Technology provides teachers and researchers with both opportunities and challenges. Teachers' confidence and attitudes toward technology may be affected by their skills and experiences with technology. Currently many types of technology resources are available to implement in physical education settings, including pedometers, accelerometers, heart rate monitors, active video games (AVG), and mobile devices (e.g., smartphones and tablets using mobile applications). Numerous researchers have investigated the effectiveness of technology in physical education, comprehensive school physical activity programs, and other physical activity and sport settings. Since there are many tools that can be used to measure student learning outcomes such as enhanced physical activity levels and skill execution, it is necessary to determine the criteria for classification for the use of technology.

In this review, the types of technologies that have been used in physical education are discussed, as well as how the technology in physical education programs had an impact on student learning outcomes. In many previous studies, technology has been used only as a measurement tool to determine the effectiveness of intervention programs. However, since technology itself can lead to positive student learning outcomes, this review discusses literature where technology was used as an intervention.

As one of representative '*Commonly Used Technologies'* for measuring physical activity (PA) levels in the physical education, the use of pedometers has been still growing rapidly (Kang, Marshall, Barreira, & Lee, 2009). Pedometers have been used as a PA measuring tool in interventions and as a motivational tool (the intervention) in programs. Along with pedometers, accelerometers, Fitbits®, and heart rate monitors are other common types of activity trackers that may encourage students to be active. The increasing reliance on '*Digital Technologies*' in educational settings has given rise to new trends in how teachers teach and students can learn. The application of digital technologies for physical activity promotion has become an attractive area of teaching and research since these types of technologies are applicable to both teachers and students (Green & Hannon, 2007). Digital technologies with the Web 2.0 base of interactive world include various domains such as social networking sites (e.g., Facebook, Snapchat, Twitter, and Instagram), user-generated contents (e.g., YouTube), and mobile devices (e.g., smartphones and tablets). Digital technology can also be recognized as an expanded notion of technology that overcomes the concept of mere information delivery systems. Over the last decade, digital technology in classroom has been recognized as digital processing systems aimed at supporting active learning, knowledge building, and innovative exploration on student learning. It also allows teachers and students to communicate with each other remotely and enables them to share data in different locations beyond the physical education classroom.

Therefore, along with the physical activity trackers, it is important to investigate the use of digital technologies in physical education because students are already adapting the technologies as a digital generation. Ninety-five percent of teens (i.e., thirteen to seventeen) reported that they have a smartphone and they are now using different kinds of online platforms such as Facebook, YouTube, Twitter, and Blogs (Pew Research Center, 2018). For the digital technology, this review will focus on the exergames/Active video games (AVGs) and mobile devices that can be used in schools to promote PA and enhance students' cognitive ability. The term 'mobile devices' consists of smartphones, iPads, tablets that include mobile applications (i.e., Apps).

Given that simply using technology as a tool may not produce innovative practices, the first purpose of this review is to conduct a systematic review of technologies (i.e., activity trackers and digital technology) used as an intervention in physical education for five years from 2013 to 2018. It will also be helpful to be more aware of current trends of the technology use in research. The second purpose of this review is to identify student learning outcomes from the use of technology (e.g., skill execution) within Physical Education curriculum.

Systematic Review of Current Use of Technologies

Overall literature search strategy. Five databases (i.e., Physical Education Index, Educational Full Text, Eric, PsycINFO, and SPORT Discus) were used for a comprehensive literature search. Various keywords were utilized to retrieve relevant studies that examined the effectiveness of technology on physical activity and student learning outcomes in physical education. The publications were limited to dates from 2013-2018. Table 1 indicates keywords sorted by categories. As categorized, keywords for independent variables (i.e., different types of technologies as an intervention) were combined with dependent variables, such as "physical activity levels" and "psychomotor skill acquisition."

Table 1

Search keywords by categories.

Category	Activity Trackers	Digital Technology
Keywords (Independent variables)	OR Pedometer* OR Accelerometer* OR Heart rate monitor* AND School* AND Intervention	Mobile device* Exergame*/Active video games (AVGs) OR Mobile Application* OR Smartphones* OR iPad* AND School* AND Intervention
Expected dependent variables	Physical activity levels, psychomotor skill acquisition	

Inclusion and exclusion criteria. The inclusion criteria for empirical study technology articles included the following: (a) peer reviewed research article; (b) it addresses the use of technology in physical education to promote physical activity or skill development; (c) studies written in English in a peer-reviewed journal; and (d) only experimental studies were included. Figures 1-5 indicate the flow chart of how the research articles were found by each keyword. Since this paper is studying the relationship between using technology and student learning and physical activity outcomes, it is important to note the exclusion criteria among the articles, indicating the accuracy of measurements, physical activity comparison between two areas, and articles that were not research papers (i.e., physical activity guidelines, review articles, and descriptive studies were also excluded).

Figure 1

Inclusion and Exclusion Criteria for pedometers

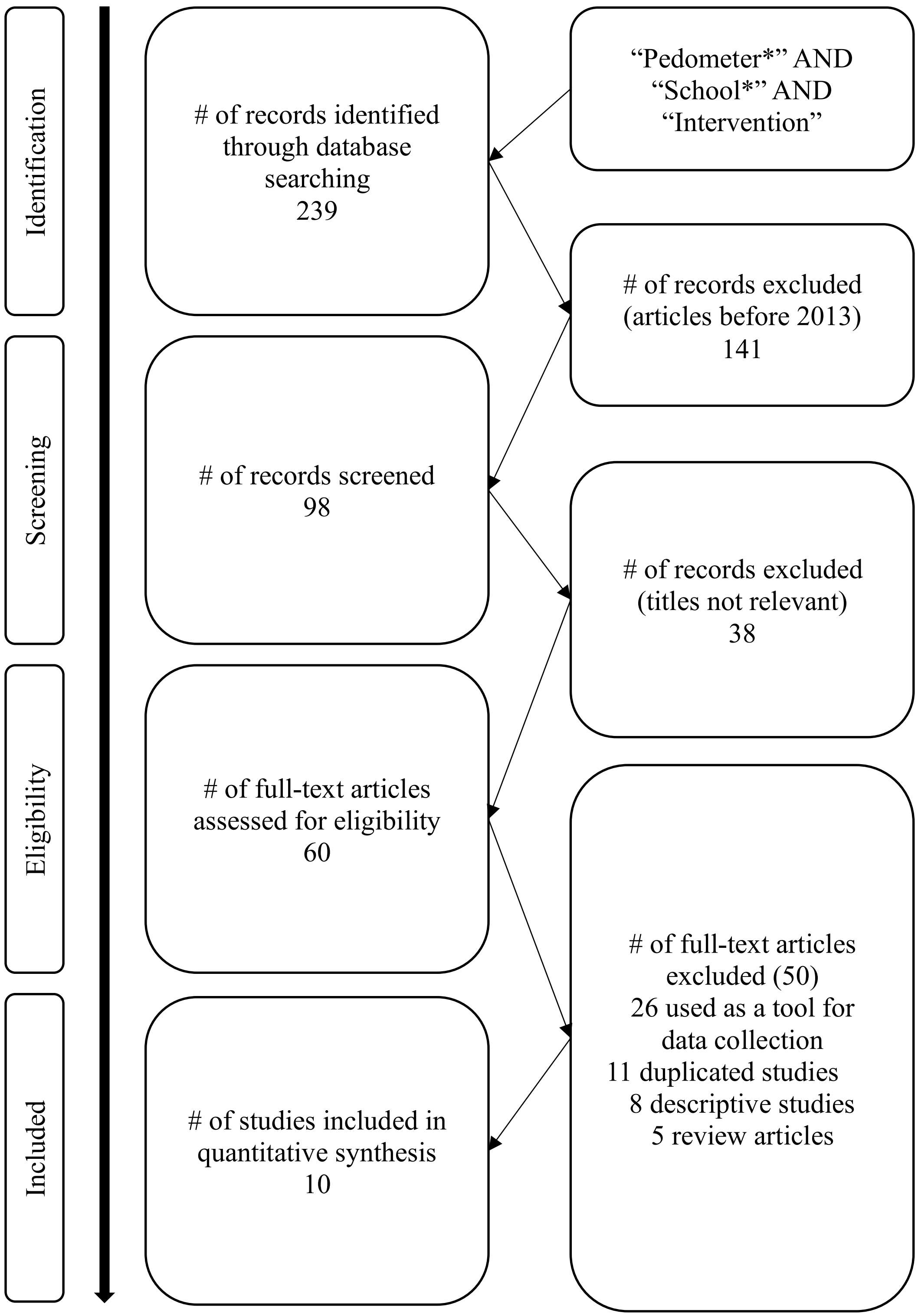


Figure 2

Inclusion and Exclusion Criteria for Accelerometers

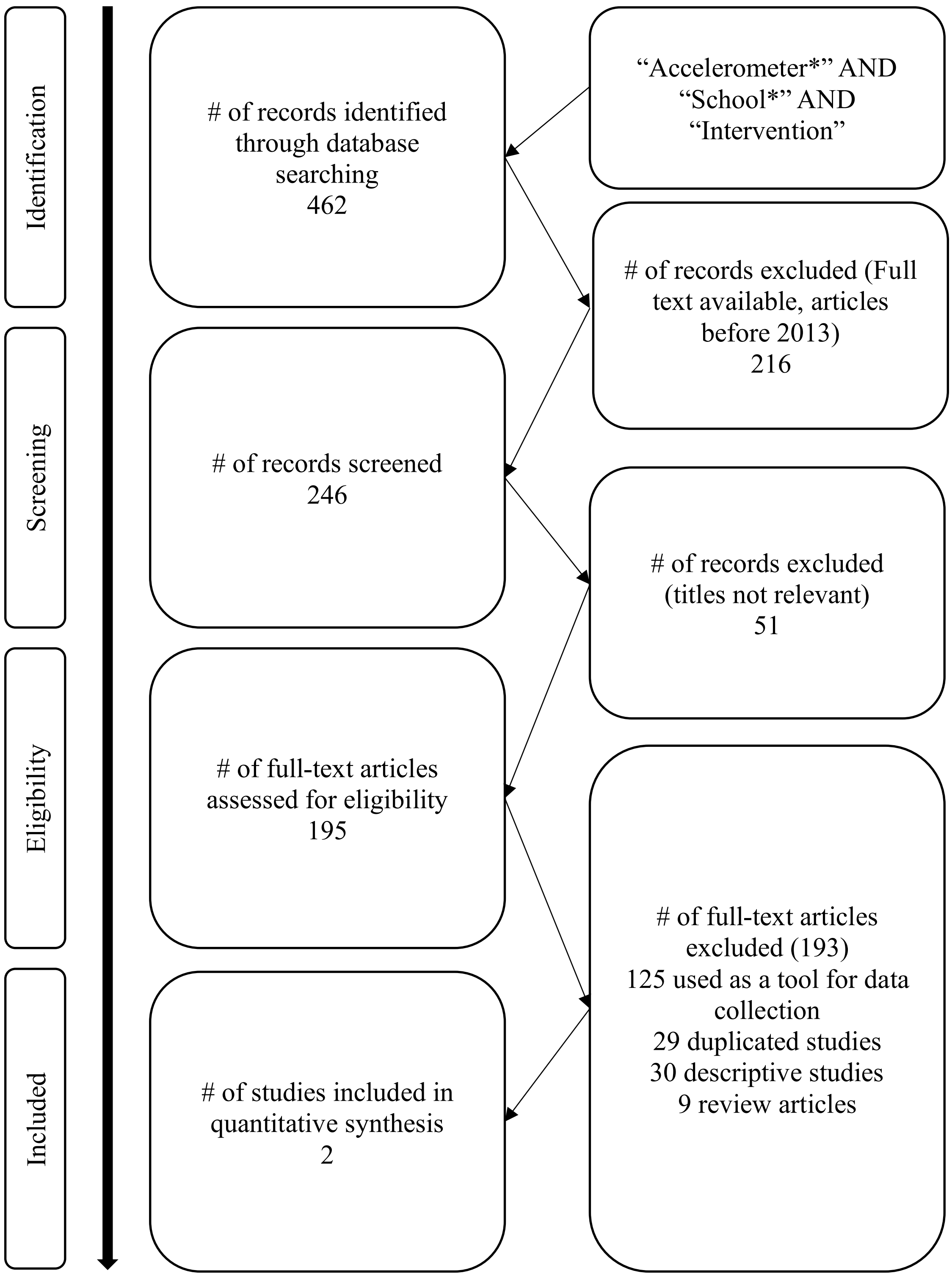


Figure 3

Inclusion and Exclusion Criteria for Heart Rate Monitors

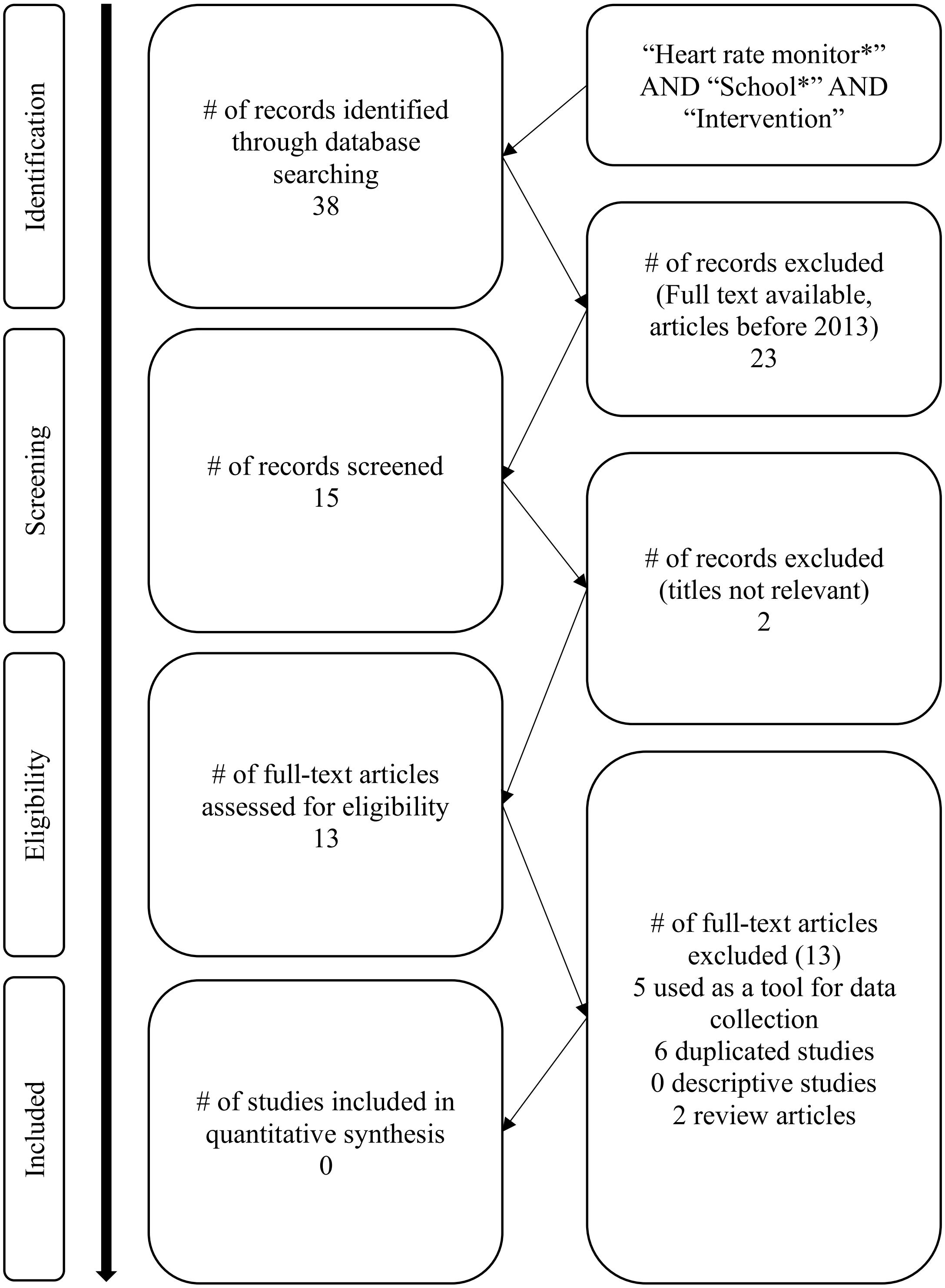


Figure 4

Inclusion and Exclusion Criteria for Exergames/AVGs

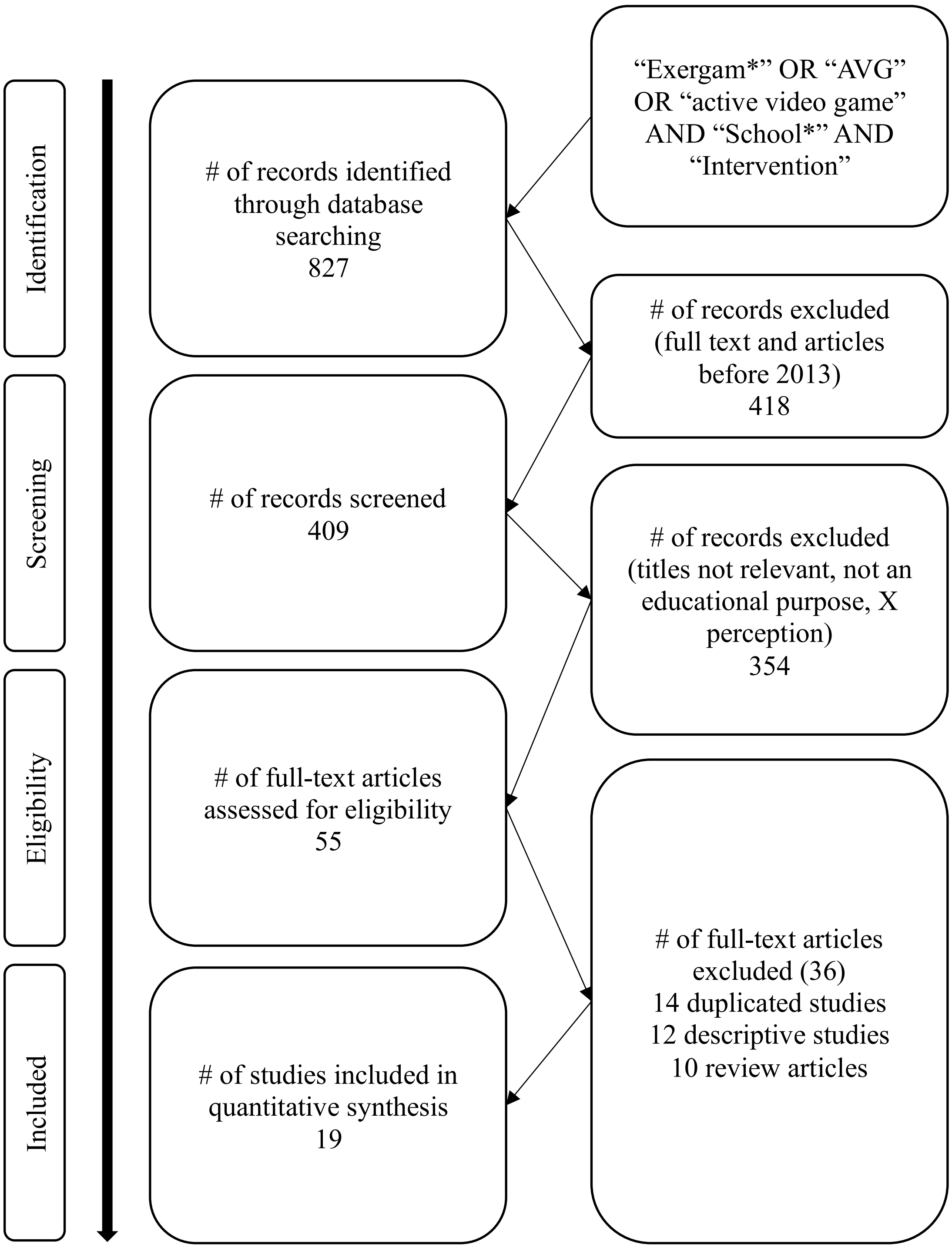


Figure 5

Inclusion and Exclusion Criteria for Mobile Devices

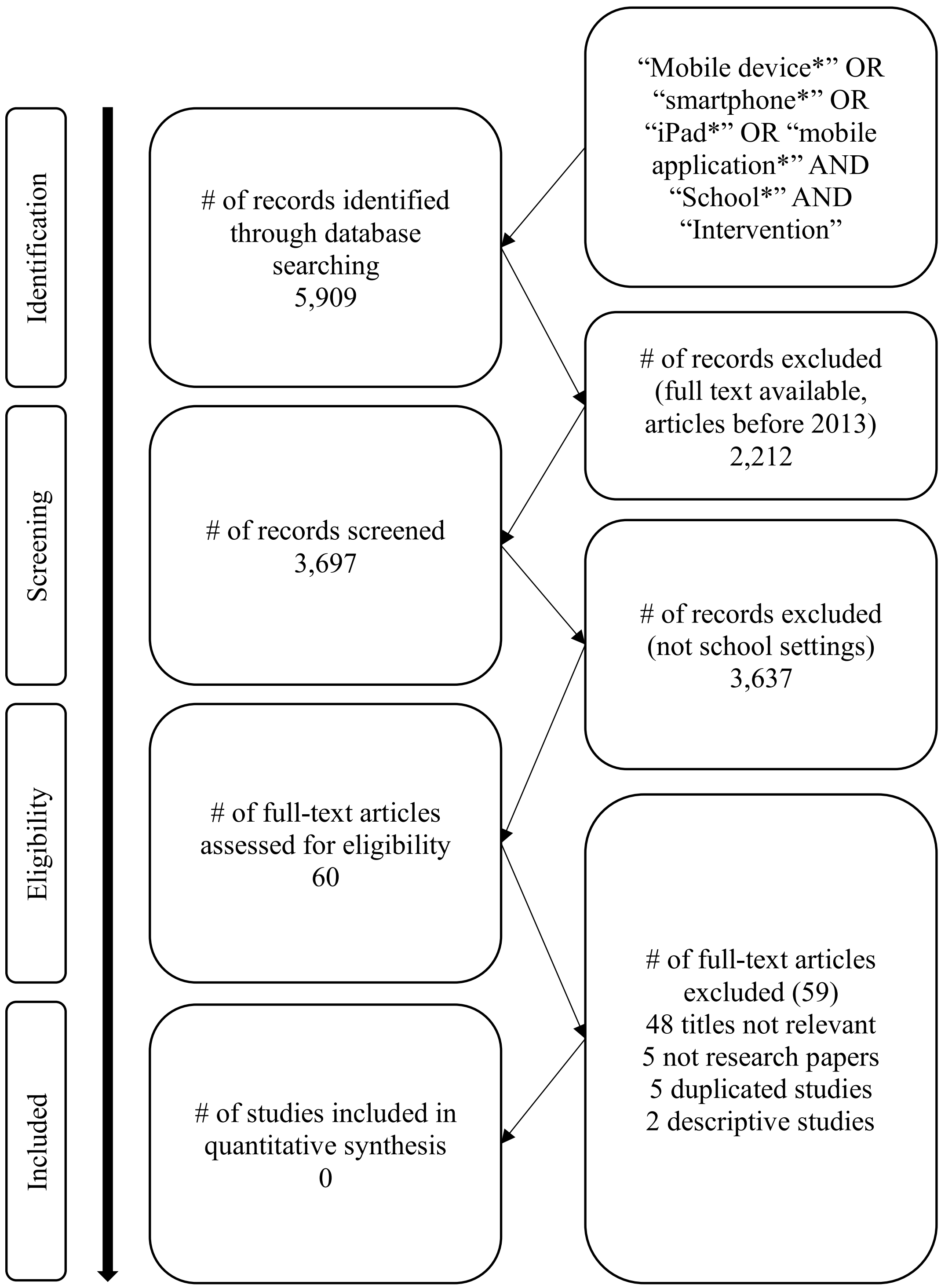


Table 2

Aims and Characteristics of Selected Papers

#	Authors	Titles	Intervention	Outcome measure(s)	Results
1	Ho, V., Simmons, R. K., Ridgway, C. L., van Sluijs, E.,M.F., Bamber, D. J., Goodyer, I. M., . . . Corder, K. (2013).	Is wearing a pedometer associated with higher physical activity among adolescents?	4-day Pedometer intervention	Counts per minute (CPM)	Significant decline in CPM over four days ($p < 0.01$). Pedometer wear was associated with higher PA among adolescent girls, but not boys. Findings may support sex-specific intervention strategies.
2	Shore, S. M., Sachs, M. L., DuCette, J. P., & Libonati, J. R. (2014).	Step-count promotion through a school-based intervention.	6-week school-based pedometer intervention (SBPI)	Grade point average (GPA), tardiness, absenteeism, and physical fitness scores	While baseline daily accrued step counts were similar, SBPI significantly increased daily accrued step counts versus control.
3	Suchert, V., Isensee, B., Sargent, J., Weisser, B., & Hanewinkel, R. (2015).	Prospective effects of pedometer use and class competitions on physical activity in youth: A cluster-randomized controlled trial.	12 weeks A cluster-randomized controlled trial with pre- and post-assessment Intervention group received pedometers and took part in a class competition	Moderate to vigorous physical activity Sedentary behavior Cardiorespiratory fitness	Students in the intervention group showed a higher increase of physical activity levels than students in the control group. School-based physical activity program (12weeks) may enhance students' leisure-time physical activity.
4	Chase, B. L., Hall, M. S., & Brusseau, T. A. (2016).	Impact of goal setting and feedback on physical activity in physical education	Lessons Step goal (2,000 steps each lesson) and feedback strategies	The total number of times each student reached the goal	The control group on average met their goal for 1.5 days The intervention group more than doubled the amount of days they met their goal.
5	Koufoudakis, R., Erwin, H., Beighle, A., & Thornton, M. L. (2016).	How feedback and goal-setting impact children's recess physical activity.	One-month Pedometer intervention Participants engaged in three conditions during recess: baseline, feedbac k, and goal-setting.	Steps Activity time	Boys were more active than the girls and the 4 super(th) grade participants were more active than the 5 super(th) grade participants.
6	Eyre, E. J., Cox, V. M., Birch, S. L., & Duncan, M. J. (2016).	An integrated curriculum approach to increasing habitual physical activity in deprived South Asian children.	6-week integrated P A intervention based on virtually walking from their school to the coast and back	Daily step counts	Average daily steps were significantly higher at post 6 weeks compared to baseline for the intervention group

#	Authors	Titles	Intervention	Outcome measure(s)	Results
7	Grao-Cruces, A., Ruiz-López, R., Moral-García, J., Ruiz-Ariza, A., & Martínez-López, E. J. (2016).	Effects of a steps/day programme with evaluation in physical education on body mass index in schoolchildren 11-12 years of age.	A six-week controlled trial with a follow-up Pedometer intervention	Body mass index (BMI) among primary education students Daily step counts	The programmed minimum number of 12,000 steps/day for boys and 10,000 for girls was exceeded by 83% of boys and 60% of girls. The differences in the number of steps/day between boys (14,274) and girls (10,626) were significant across all the measured periods.
8	Hyun-Ju, O., & Rana, S. (2017).	Using a 3-Day Physical Activity Recall as Homework to Increase Physical Activity in Rural Appalachian School Youth: A 3-Week Pilot Intervention Program.	6-week intervention Pedometer intervention for 7 days at pre- and posttest.	Step counts on pre- versus posttest for the whole week, weekdays, and weekends.	Youth who completed the 3DPAR-delivered intervention significantly increased their step counts on the weekends.
9	Gu, X., Chen, Y., Jackson, A. W., & Zhang, T. (2018).	Impact of a pedometer-based goal-setting intervention on children's motivation, motor competence, and physical activity in physical education.	8-week intervention (3 days/week for 24 sessions) A pretest-posttest comparison group design	Expectancy-value beliefs Motor competence Physical activity level	Experimental groups had significantly higher expectancy-value beliefs, motor competence, and physical activity compared to the control group.
10	Miller, B. G., Valbuena, D. A., Zerger, H. M., & Miltenberger, R. G. (2018).	Evaluating public posting, goal setting, and rewards to increase physical activity during school recess.	59 sessions of school recess	Mean steps per minute across the entire class	In the absence of self-monitoring, performance feedback alone did not increase physical activity levels above those observed during baseline. Additionally, higher levels of physical activity were observed when goal-setting was introduced.
11	Guthrie, N., Bradlyn, A., Thompson, S. K., Yen, S., Haritatos, J., Dillon, F., & Cole, S. W. (2015).	Development of an accelerometer-linked online intervention system to promote physical activity in adolescents.	6-week intervention	Average MVPA levels	Zamzee intervention had average MVPA levels 54% greater than those of a passive control group and 68% greater than those of an active control group that received access to a commercially available active videogame. Zamzee's effects on MVPA were statistically significant in both females and males, and in normal- vs. high-BMI subgroups.

#	Authors	Titles	Intervention	Outcome measure(s)	Results
12	Clevenger, K. A., Moore, R. W., Suton, D., Montoye, A. H. K., Trost, S. G., & Pfeiffer, K. A. (2018).	Accelerometer responsiveness to change between structured and unstructured physical activity in children and adolescents.	3-year period	Standardized response means (SRM)	Accelerometry was sensitive to differences in physical activity associated with structured compared t o unstructured play, supporting the utility of accelerometry in evaluatin g activity promoting interventions.
13	Sheehan, D. P., & Katz, L. (2013).	The effects of a daily, 6-week exergaming curriculum on balance in fourth grade children.	6-week period, 34 min per day, 4-5 days per week	Agility, balance, and coordination	Exergaming students improved their postural stability significantly over a 6-week period compared to those in the typical PE class. Postural stability in the girls was better than the boys in all pre- and post-intervention tests.
14	Staiano, A. E., Abraham, A. A., & Calvert, S. L. (2013).	Adolescent exergame play for weight loss and psychosocial improvement: A controlled physical activity intervention.	20-week intervention Competitive exer game, cooperative exerg ame, or control conditions.	Weight Self-efficacy	Cooperative exergame pla yers lost significantly more weight than the control group, which did not lose weight. The competitive exergame pla yers did not differ significantly from the other conditions. Cooperative exergame pla yers also significantly increased in self-efficacy compared to the control group, and both exergame conditions significantly increased in peer support more than the control group.
15	Thin, A. G., Brown, C., & Meenan, P. (2013).	User experiences while playing dance-based exergames and the influence of different body motion sensing technologies.	Six comparable dance routines selected from commercial dance-based exergames	Level of physical exertion Difficulty, and enjoyment	No differences were found in the physiological measures of exertion between the peripherals/consoles. Significant variations in the difficulty and enjoyment ratings between peripherals.
16	Ružić, L., Mohar, S., & Radman, I. (2014).	Interactive dance: An exciting way to enhance children's physical activity level.	"iDance" class ("iDance"; Positive Gaming (TM)).	Heart rate Energy expenditure Perceived exertion	The children exercised at the moderate intensity. In 86% of participants the activity was perceived as light

#	Authors	Titles	Intervention	Outcome measure(s)	Results
17	Meckbach, J., Gibbs, B., Almqvist, J., & Quennerstedt, M. (2014).	Wii teach movement qualities in physical education.	Three sixty minutes of Physical Education lessons	Movement qualities (body, effort, space, and relations)	Students while playing dance games use a wider variety of movement qualities than in sport and exercise games.
18	Gao, Z., Stodden, D., Huang, C., & Feng, D. (2014).	Impact of exergaming on elementary children's physical activity levels.	Baseline 5-day moderate-to-vigorous PA (MVPA) Exergaming group (125-min weekly structured PA programs Control group (125-min weekly physical education).	Moderate-to-vigorous PA (MVPA)	Significant main effect for time and for intervention. Both intervention children and control children had significantly greater increased MVPA over time. Also, control children had significantly higher MVPA compared with intervention children at both baseline and posttest.
19	Gao, Z., & Xiang, P. (2014).	Effects of exergaming-based exercise on urban children's physical activity participation and body composition.	Fourth graders: intervention group engaging in 30 minutes exergami ng- based activities 3 times per week Third and fifth graders: comparison group. 9 months later (posttest) Interviews	Physical activity levels Body fat change	Intervention children had significantly greater increased physical activity levels than comparison children. Intervention children did not differ significantly in percent body fat change from comparison children. Children interviewed reported positive attitudes toward the intervention.
20	Hulteen, R. M., Ridgers, N. D., Johnson, T. M., Mellecker, R. R., & Barnett, L. M. (2015).	Children's movement skills when playing active video games.	Skill assessment before AVG play Observed once a week for 6 weeks while playing AVGs for 50 min.	Skill execution	Nearly all skills were more correctly performed during skill assessment (generally more than 50% of the time).
21	Gao, Z., Chen, S., & Stodden, D. F. (2015).	A comparison of children's physical activity levels in physical education, recess, and exergaming.	Beyond the daily 20-minute recess, participants attended 75-minute weekly physical e ducation classes and another 75-minute weekly exergami ng classes.	Physical activity levels	Children's MVPA in exer gaming and recess was higher than in physical education. The 2nd-grade children demonstrated lower sedentary behavior and MVPA than the first-grade children during recess; less light PA in both recess and exergaming than first-grade children; and less sedentary behavior but higher MVPA in exergaming tha n first-grade children.

#	Authors	Titles	Intervention	Outcome measure(s)	Results
22	Pope, Z. C., Lee, J. E., & Gao, Z. (2016a).	Effects of exergaming on urban children's physical activity and fitness.	8-month school-based exergaming intervention 81 4th-grade students	Physical activity and fitness (half-mile run)	A significant Time & Group interaction for sedentary behavior and MVPA with no significant interactions seen for low physical activity, half mile run times, or physical activity intention. The intervention children increased MVPA over time (29-min increase), while the control children experienced only a slight increase (4.2-min increase). A significant difference in MVPA emerged between the 2 groups over time, favoring greater MVPA among intervention children.
23	Pope, Z. C., Lee, J. E., & Gao, Z. (2016b).	Exergaming and children's before-school and afterschool physical activity behaviors.	8-month school-based exergaming intervention 81 4th-grade students A once-weekly 50-min recess-based exergaming program throughout the school year	before-school and afterschool physical activity (PA) and screen time (ST)	A significant Time & Group interaction for before-school active ST, and afterschool ST. The duration of before-school active ST increased among intervention children but decreased among control children over time.
24	Gao, Z., Lee, J. E., Pope, Z., & Zhang, D. (2016).	Effect of active videogames on underserved children's classroom behaviors, effort, and fitness.	95 fourth grade children from three classes 50-minute weekly AVG program at school for 6 weeks	Task classroom behavior, academic effort, and fitness	Significant effect on children's effort between the first and last week assessments Significant effect on classroom behavior. No significant improvement in cardiovascular fitness
25	Gao, Z., Lee, J. E., Stodden, D., Roncesvalles, N., Pasco, D., & Huang, C. C. (2016).	Effect of exergaming on children's energy expenditure and physical activity.	260 2nd- and 3rd-grade children Experimental unit for 2 years: (a) exergaming intervention group (alternating 125-min PE and 125-min exergaming biweekly) and (b) control group (125-min PE class weekly).	Energy expenditure (EE) and PA	Significant increase in MVPA, and LPA in Year 1, yet greater decreases in Year 2

#	Authors	Titles	Intervention	Outcome measure(s)	Results
26	Johnson, T. M., Ridgers, N. D., Hulteen, R. M., Mellecker, R. R., & Barnett, L. M. (2016).	Does playing a sports active video game improve young children's ball skill competence?	Two group pre/post experimental design study 36 children 6 × 50 min lunchtime AVG sessions on the Xbox Kinect.	Children's actual and perceived object control skills	No significant differences between the control and intervention groups
27	Garde, A., Umedaly, A., Abulnaga, S. M., Junker, A., Chanoine, J. P., Johnson, M., . . . Dumont, G. A. (2016).	Evaluation of a novel mobile exergame in a school-based environment.	Mobile Kids Monster Manor (MKMM) 42 students 4-week crossover study to evaluate the game intervention	Step count and active minutes	Greater increase in steps and active minutes per day among children
28	Lee, J. E., Gao, Z., & Stodden, D. (2016).	Impact of exergaming on children's fundamental motor skills and fitness.	261 2nd- and 3rd-grade children Experimental unit: (a) exergaming intervention group (alternating 125-min PE and 125-min exergaming biweekly), and (b) comparison group (125-min weekly PE).	Fundamental motor skill and health related fitness	Significant interaction effects for cardiorespiratory fitness and musculoskeletal fitness but not FMS Comparison children (55.02) displayed significantly higher cardiorespiratory fitness scores than intervention children (45.59) at baseline, but their fitness (53.95) decreased at posttest while intervention children's scores increased (46.56). Comparison children's muscle strength decreased (50.51/49.70) while intervention children's increased (48.89/51.08) over time.
29	Chen, H., & Sun, H. (2017).	Effects of active videogame and sports, play, and active recreation for kids physical education on children's health-related fitness and enjoyment.	29 third graders in SPARK physical education group and 36 in the Kinect AVG group 6 weeks, with each week including three practice sessions	Health-related fitness and physical activity (PA) enjoyment	AVG group had greater improvement in 15-m PACER test, as well as PA enjoyment than those in SPARK group. The AVG group generated higher light PA and lower sedentary time for three and two sessions, respectively. AVG group accumulated higher moderate-to-vigorous physical activity (MVPA) for the first session, while the SPARK group generated higher MVPA for the third session.

#	Authors	Titles	Intervention	Outcome measure(s)	Results
30	Lee, J. E., Xiang, P., & Gao, Z. (2017).	Acute effect of active video games on older children's mood change.	68 third and 66 fourth grade children co mpleted the Brunel Mood Sca le (BRUMS) immediately before and after attending a 30-min AVGs session.	Children's mood change	A short bout of AVGs significantly reduced anger/depression and vigor, and fourth grade children had greater vigor than the third graders.
31	Rincker, M., & Misner, S. (2017).	The Jig Experiment: Development and Evaluation of a Cultural Dance Active Video Game for Promoting Youth Fitness.	404 elementary children 5 day-intervention Group 1 - AVG instruction. Group 2 - face-to-face lessons Group 3 - AVG and face-to-face lessons	Dance mastery score Heart rate Satisfaction	AVG students achieved comparable levels of mastery, significantly elevated heart rates, and high levels of satisfaction.

Findings from the Systematic Review

This systematic review aimed to determine the use of technology as an intervention in physical education classes. Figures 1-5 show the results of this systematic review and study inclusion and exclusions. The initial searches in five databases returned a total of 7,475 full text articles prior to de-duplication (i.e., pedometer 239; accelerometer 462; heart rate monitor 38; exergaming 827; and mobile devices 5,909 articles). The articles published before 2013 (*N* = 3,010) were excluded to focus on current articles that included technology as an intervention. Following title and abstract review, 398 articles were retrieved for eligibility (i.e., pedometer 60; accelerometer 195; heart rate monitor 13; exergaming 55; and mobile devices 60). Finally, a total of 31 studies met the search criterion in this review. The study information and outcomes of included studies are shown in Table 2. The grade ranged from first to eighth grade participants and the study duration was from three days to eight months. The number of participants varied from 19 to 1,162. Four studies described goal setting with activity trackers as interventions. PA level was the main dependent variable and the additional results from the studies such as gender differences (5), cognitive engagement/executive functions (1), skill development (1) and students' attitudes and enjoyment (6) were identified. Only one study reported that the authors found no positive effects of the use of technology on PA.

The cumulative evidence in this review suggests that the use of technology as an intervention has a positive effect of the increase of PA levels in physical education settings. Twelve studies used activity trackers as an intervention (i.e., pedometers and accelerometers) and were included in this review. Notable is the fact that there were no studies using heart rate monitors as an intervention in the last five years. In 19 out of 31 articles, exergames and AVGs were used as an intervention. Interestingly, no study was found that included the use of mobile devices as an intervention in physical education settings. Palao, Hastie, Cruz, and Ortega (2015) reported the negative perceptions from the teacher due to the significant time cost although the teacher had the positive feeling of the intervention.

Potential Benefits of Digital Technology in Educational Settings

The impact of using technology on various student outcome measures is reflected in the studies listed in Table 2. Technology enhanced health related fitness, executive function, cooperation, and enjoyment, fostering the development of communication. With all the benefits from the use of digital technology, it is suggested that technology may help in authentic game and sport situations that even lead to the development of affective dispositions for students in physical education. However, it is important to note that there were only two studies that focused on skill acquisition/development. Further research will be warranted to demonstrate the effectiveness of the use of digital technology on motor skill development.

Physical activity trackers. Physical activity participation levels have been one of important outcomes in physical education. Burke, Wang, and Sevick (2011) found that self-monitoring is one of key strategies to enhance individuals' physical activity. Over the past five years, twelve studies showed that pedometers and accelerometers have been used as self-monitoring tools, demonstrating effective results in understanding PA patterns among adolescents because of their cost-effective approaches and ease of use (Brusseau & Hannon, 2013; Goode et al., 2017). These activity trackers have been recently digitalized so the data can be immediately and automatically collected and analyzed after students or other participants' physical activity.

Exergaming/AVG. Nineteen articles using exergaming as an intervention program with outcome measures other than physical activity levels (e.g., fundamental motor skill, health related fitness, enjoyment, balance, mood change, and skill execution). For skill development as an outcome measure, two studies found significant differences between experimental (i.e., with technology) and control groups in skill execution (Hulteen, Ridgers, Johnson, Mellecker, & Barnett, 2015; Lee, Gao, & Stodden, 2016), while one study found no difference between conditions in skill development (Johnson, Ridgers, Hulteen, Mellecker, & Barnett, 2016). The rest of the studies that used exergames showed a positive impact on their outcome measures including entertainment, challenge, and reward. It could be argued that one of the weaknesses of exergaming is that tailoring exergames is costly and it takes time for teachers to install the games in their gym, therefore, it may be done less frequently in physical education settings. In spite of the budget and technical considerations of exergame technology, more study investment in this area will be needed. Rincker and Misner (2017) showed that using exergaming with students has been advancing, affordable, and is developing in potential opportunities for diverse learning outcomes for future development in physical education.

Mobile devices. While almost 5,909 articles using mobile devices were published in just the last five years, no study using mobile applications as the intervention in physical education settings was found. In spite of the fact that there were recommendations for using mobile devices in physical education classes (Cummiskey, 2011; Trout, 2013; Yu, Kulinna, & Lorenz, 2018), there is no evidence to claim the effectiveness of using mobile devices on student learning outcomes in physical education. Even though physical educators may know about the potential positive aspects of using mobile devices, there is no evidence of them using such tools in their teaching.

Along with exergames, using mobile devices (e.g., mobile Apps) has the potential to benefits students to achieve their goals. It could potentially also help teachers select a variety of pedagogical strategies and be open to nontraditional ways of teaching. Therefore, further studies are necessary to determine better ways to use digital technologies (e.g., mobile devices) that could result in effective teaching and learning.

Challenges in the Use of Technology in Physical Education

The primary purpose for using technology in physical education may be to support teachers in instructional delivery and to help students to learn skills and knowledge related to their subject matter. The recent studies of emerging digital mobile technology regarding the availability and application thereof, have resulted in both promoting opportunities and demands for physical education teachers to integrate technology into their classroom. Given that there are various ways for technology integration, considerations for pedagogical uses of technology are needed beyond the level of just touting technology as a tool.

Despite that there are an ever-growing number of technologies available to physical education teachers, the use of digital technology, has been limited by several barriers (Hew & Brush, 2007). The findings from this systematic review also showed the lack of evidence of teachers using mobile technology in physical education. Hew and Brush (2007) found 123 barriers for using technology from previous empirical studies and classified them into six categories: (a) resources (e.g., technology, access to available technology, time, and technical support), (b) knowledge and skills (e.g., technology knowledge and skills, technological pedagogical knowledge and skills, and classroom management knowledge and skills using technology), (c) institution (e.g., leadership, school time-tabling structure, and school planning), (d) attitudes and beliefs towards technology, (e) measurement of student learning (i.e., assessment), and (f) subject culture shaped by content and pedagogy (e.g., reluctance to adopt a technology that seems incompatible with the norms of a subject culture).

Further research regarding the way how schools can support the use of digital technology in Physical Education classes will be needed. Collaboration between practitioners and researchers should be encouraged, because schools can allow teachers to explore innovative uses of digital technologies as well as combinations of analog technologies into digital environments and researchers can allow schools to carry on the pedagogical practices with financial supports. Effective choice of technology is just a starting point of the learning process. Consideration of what will students learn and how the analog and digital technology help them is fundamental to its next steps.

CHAPTER 3

THE EFFECTS OF MOTION ANALYSIS APP ON MIDDLE SCHOOL STUDENTS' BADMINTON SKILL AND GAME PERFORMANCE IN PHYSICAL EDUCATION

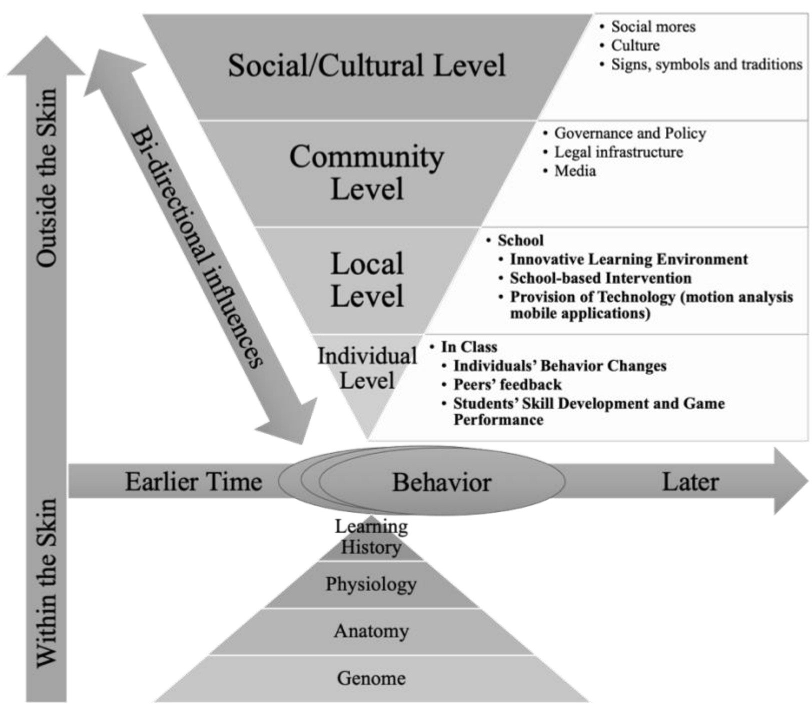
Video technology in physical education has been used regularly in many schools and universities (Miller & Gabbard, 1988; Palao, Hastie, Cruz, & Ortega, 2015; Rikli & Smith, 1980; Van Wieringen, Emmen, Bootsma, Hoogesteger, & Whiting, 1989; Weir & O'Connor, 2009; Zetou, Tzetzis, Vernadakis, & Kioumourtzoglou, 2002). Teachers may be able to use several effective teaching methods while using video technology: (a) give immediate feedback after a performance, (b) use verbal and visual feedback at the same time, (c) save and use the video data frequently and repeatedly, and (d) compare former and later performances visually.

Mobile Applications (APPs) using mobile devices, as an advanced video technology, provide another vehicle for teachers to deliver content and assist with teaching while reducing the burdens of using technology because the mobile devices are easy to set up and use. Using mobile applications may enable teachers to broaden their knowledge and teaching skills as well as save time in helping students develop their motor skills by using instant, augmented feedback. However, even though teachers are aware of how the video technology plays an important role in enhancing performance of motor skills, they are less likely to use technology if it is too complex to easily use (e.g., Tannehill, van der Mars, & MacPhail, 2015; Palao et al., 2015). Palao et al. (2015) addressed the significant time cost and insufficient technology competencies as teachers' barriers to their teaching with technology.

Skill performance is one of the most important determinants of ‘success’ in increasing participation during competitive sports (Locke & Latham, 1985). Carlson (1995) found that 66% of students who showed apathy toward physical education classes were below average in physical skills and demonstrated a lack of sports knowledge. Therefore, the importance of acquiring fundamental sports skills should be emphasized in the process of learning to play different sport activities. For instance, if students have strong fundamental striking skills associated with net-court games, they are more likely to have success on net/court sports such as a tennis, badminton, pickleball, and racquetball. It is also important to note that students will be able to become actual players by having opportunities to practice tactical moves in different game contexts (Kolman et al., 2019; Low et al., 2019; Sampaio & Maçãs, 2012; Sansone et al., 2020).

Figure 6

Behavioral Ecological Model adapted from Hovell et al. (2009)



This study was informed by the Behavioral Ecological Model (BEM) theoretical framework. In the BEM, the acquisition and maintenance of learned human behavior is the result of direct/indirect and interactive relationship between an individual and their interactions in the same environment (Hovell, Wahlgren, & Adams, 2009). Figure 6 represents the complex mechanism of individual's behavior and his/her interaction with the environment. The BEM framework is useful for understanding factors that determine behaviors at varying levels (e.g., individual, local, societal). In the current study, this school-based intervention (framed within the BEM) was tested at individual and local level. The new environment situation as an antecedent event (e.g., motion analysis App use in physical education class) can potentially provide individuals with positive reinforcement for learning at individual and school level.

Sport Education Model (SEM) Context

SEM is one of the *quality physical education* (QPE) instructional models that supports students being competent, literate, and enthusiastic sportspersons (Metzler, 2017; Siedentop, Hastie, & van der Mars, 2020). The aspect of competent sportsperson in SEM provides students with authentic and developmentally appropriate sport-based experiences for students to be a skillful person (Siedentop et al., 2020). The effectiveness of SEM for impacting skill development and game play has been summarized by several researchers (e.g., Harvey, Kirk, & O'Donovan, 2014; Hastie, Martinez de Ojeda, & Calderón Luquin, 2011; Wallhead & O'Sullivan, 2005).

Even though there is evidence to support that, compared to traditional physical education units, SEM improve skill development in well-taught Sport Education contexts, little is known about the effects of how the use of digital video technology (e.g., mobile applications) in SEM seasons might provide a value-added impact on student learning. To date, no prior intervention studies have been conducted on the effectiveness of using mobile applications in physical education classes using any curricular model. Therefore, purpose of this study was to determine the effects of using a motion analysis mobile application on students' skill development and game play in physical education within the context of badminton. Accordingly, the main research questions were as follows: (a) does use of the digital movement analysis App (*Hudl Technique*) improve students' badminton skill execution in a badminton season?; (b) does the video-based feedback using *Hudl Technique* improve students' game play? In the current study, it was hypothesized that App video technology would help students improve their skill development and game performance in physical education using the Sport Education curricular model.

Methods

Participants and Settings

The participants included two eighth grade classes from one junior high charter school in the southwestern US. The urban K-8 school had 1,150 students (64.7% White, 19.2% Hispanic, African American 5.2%, and 0.6% American Indian/Pacific Islander), with 19.5% of students eligible for free/discounted lunch. There were approximately an equal number of male and female students in the school. This charter school provides daily physical education for middle school students.

One physical education teacher (male, Caucasian), experienced in using the SEM with over seven years of teaching experience, taught two classes using SEM with mobile application intervention. The school had adequate physical activity facilities and equipment for this study including a maximum of four indoor badminton courts and two outdoor grass fields. The University's and the School District's Institutional Review Boards approved the study prior to any data collection (Appendix I). Parental consent and students' assent were obtained for this study (Appendix II).

Target Behaviors (Dependent Variable)

Performance changes in skill execution and game play were assessed, including: (a) students' badminton clear shot performance on a clear shot skills test and (b) game-play performance through students' skill execution, decision making, and base. Skill execution (SE) refers to the success (i.e., the outcome/result) of various shots. If a serve was successful or if the performer hit a shuttle with different shots over the net and the shuttle landed within the opponent's court during an episode of one scoring, the response was coded as appropriate.

Decision Making (DM) refers to the ability to move an opponent from the base position. If the performer showed proper shot making with different shot direction and angle to give the opponent space pressure situations, the decision was coded as appropriate. Base (BA) refers to the ability of a player to return to a base position after executing a stroke. If the performer showed the court coverage by quickly returning after every shot, the response was recorded as appropriate.

Intervention (Independent Variable)

The intervention consisted of the use of the *Hudl Technique* App, which is a 'motion video analysis' mobile application that can be used to record a person's motor performance. Students' motor skill performance can be improved by analyzing their motion/movement, providing immediate feedback through the App. Teachers (or sport coaches) can highlight aspects of the performer, and possibly provide augmented prompts and/or feedback. The *Hudl Technique* also has various additional features such as slow-motion speed (1/8, 1/4, or 1/2), frame-by-frame forward and -backward play, and a zoom function that help the teacher to examine specific skill movements such as foot work or wrist action in badminton.

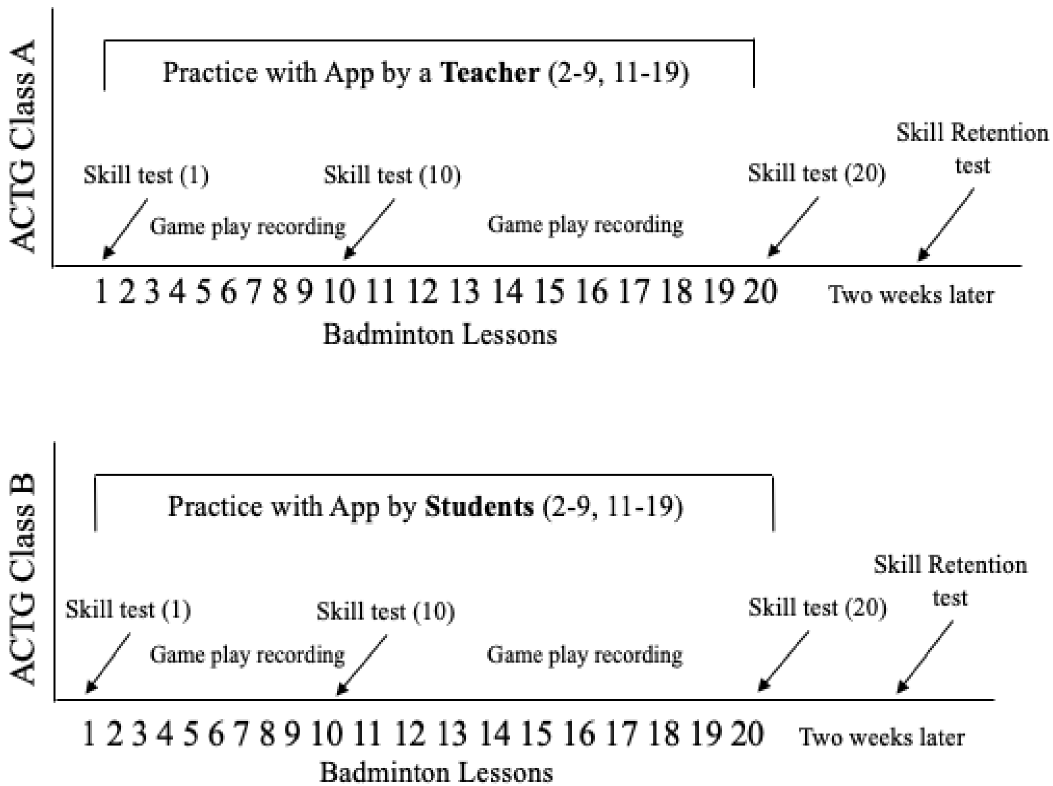
Research Design

A modified Alternative Control Treatment Group (ACTG) design (Borg, 1984; van der Mars, 1990) was applied to rule out or at least minimize five threats of internal validity: (a) experimental mortality (differential loss from comparison group), (b) diffusion or imitation of treatment (interaction between experimental and control group), (c) compensatory equalization of treatments by providing the control group with benefits from other sources, (d) compensatory rivalry by respondent receiving less desirable treatment; John Henry effect, and (e) resentful demoralization of respondent receiving less desirable treatment; type 1 error. In addition to ruling out the threats of internal validity, advantages from this research design are that researchers get an increased number of participants and all the participants receive the benefit from the intervention.

The main difference between two classes was who used the App (only teacher in (Class A) and students in (Class B). This research design provided researchers with information regarding the effectiveness of the technology integration as well as the suitable timing for technology integration at the same time. Figure 7 shows a graphic prototype of the ACTG design, which will give an overall process of tests during a badminton season.

Figure 7

Graphic Prototype of the Modified ACTG Design (Borg 1984; van der Mars, 1990).

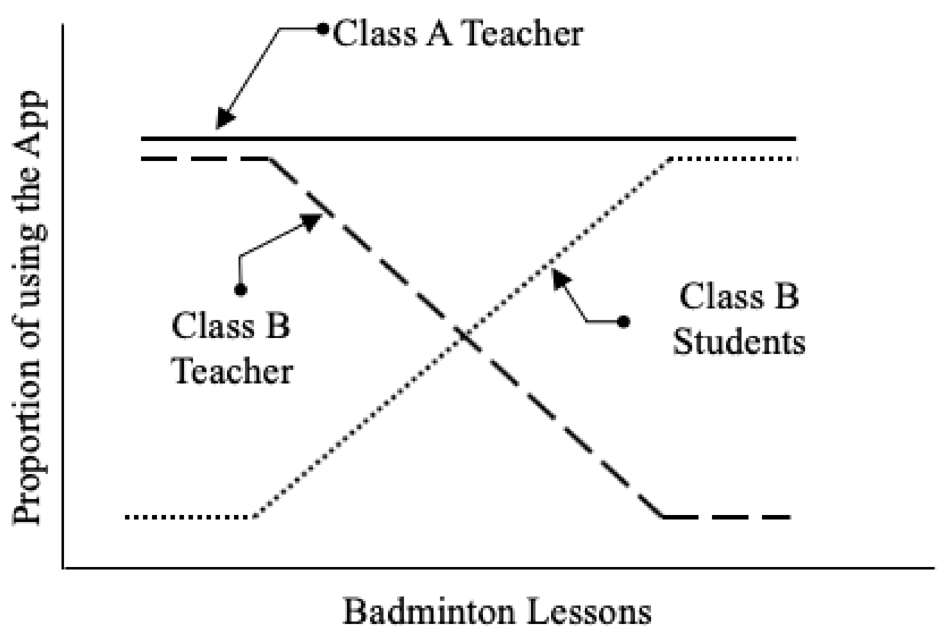


At the junior high, one class was randomly assigned into one of two experimental groups, with the App being used in both experimental classes. Participants in each class consisted of five teams based on their skill levels that were pre-determined by the physical education teacher. For both experimental classes, a 17-day intervention (out of 20-day lessons) was delivered that focused on students' skill and game play development during the badminton season. Both intervention classes were also tested four times on the skill test (including the retention test) and game play was recorded throughout all badminton lessons.

A week before the badminton season started, the physical education teacher in this study was trained in how to use the *Hudl Technique* App. The teacher and students used the App in the two intervention classes to determine if it improved the students' skill execution and tactical moves during game play. In Class A, from lesson 2 on, only the physical education teacher used the App to give student immediate visual feedback. In Class B, the teacher explained how to use the motion analysis App using iPads and let students gradually have responsibility for using it within their teams (with each team having its own iPad). Figure 8 shows the proportion of the use of mobile App between the teacher and students in Class B. Students received skill feedback from the teacher or peers either orally or with the iPad using the motion analysis App.

Figure 8

The Ratio of Using Mobile App between a Teacher and Students



Fidelity of Treatment

To ensure the appropriate delivery of the intervention (as intended), the amount of time and the number of times that the teacher and students spent on using the motion analysis App during the team practice was monitored throughout the badminton season. The number of videos they recorded were counted in each class and they were asked to leave voice recordings when they reviewed their plays to better understand the ways they were using the App.

Procedures

A pilot study was conducted prior to the data collection, to work out logistical issues (Appendix IV). During the actual study, intervention data were collected on students' skill performance (i.e., forehand overhead clear), game play performance, and the opportunity to respond (OTR) of a sample of both high- and low-skilled students.

One class was randomly assigned into each of the intervention groups (Class A and B). Participants in each class consisted of five teams based on their skill levels that were pre-determined by the physical education teacher. For both experimental classes, a seventeen-day intervention out of twenty-day lessons were delivered that focused on students' skill and game play development during the badminton season.

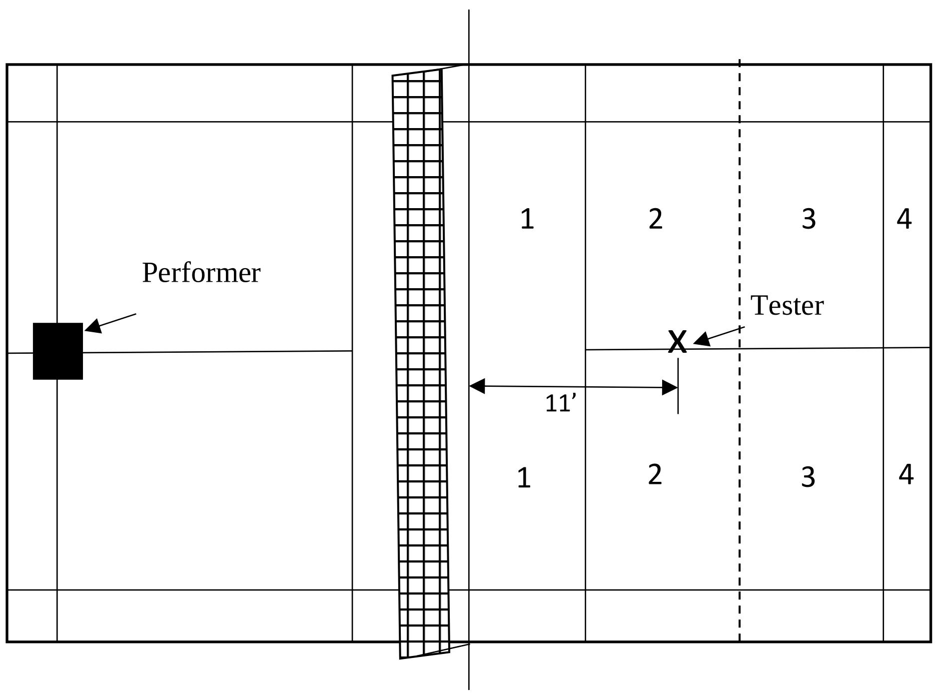
Students participated in two game plays for 20 minutes from the fourth day on during badminton season. Four courts were positioned for four teams in quadrants around the school gymnasium, while the fifth team would practice in the center of the gymnasium. The teacher started and stopped the games so that all players were playing at the same time. One iPad was positioned on each court to detect the targeted students' skill execution and tactical skills during games.

Data Collection

Forehand Overhead Clear Skill Performance. To collect data on this technique, the *Poole Forehand Overhead Clear Test* (French, Werner, Rink, Taylor, & Hussey, 1996) was used. A trained tester stands at point 'X' while holding a racquet overhead. The performer stands on the black square spot with her/his foot (right-handed - right foot, left-handed – left foot) and receives a shuttle from a trained tester to hit it back over the net to the deepest corner of the court. The performer gets to hit a shuttle 20 times with an overhead forehand clear over the tester's racquet. Figure 9 displays the test set-up. The maximum score is 80 points (up to 4 points per trial).

Figure 9

Poole Forehand Overhead Clear Test



Game play Performance Data. Using video records of the games played during the badminton season, game performance was assessed using the following indices: skill execution, decision making, and base. Each student's game play was videotaped throughout the badminton season except for the skill test days and research field notes were taken to record the process of using the App for the teacher and the students throughout the season.

Students' game play performance was assessed during their first and last formal competition by reviewing the game videos. Three high-skilled and three low-skilled students in each class were randomly selected to measure game performance throughout the badminton season for further data analysis. Since the assessments for game play (tactical movement) were conducted with video recording after lessons, it did not affect any part of the badminton lessons.

Table 3

Adapted Game Components in GPAI (Oslin et al., 1998)

Game component	Description
Decision making	Makes appropriate decisions about what to do with the ball (or projectile) during a game
Skill execution	Efficient execution of selected skills
Base	Appropriate return of the performer to a recovery (base) position between skill attempts

The game performance assessment instrument (GPAI). GPAI adapted for badminton was used (Oslin, Mitchell, & Griffin, 1998). Oslin et al. (1998) developed seven observable components (i.e., decision making, skill execution, adjust, cover, support, guard/mark, and base) to identify the applicable game performance across all types of game categories. For the purpose of this study, three GPAI components (i.e., skill execution, decision making, and base) indices were used (see Table 3).

Calculating GPAI Indices. The tally scoring method introduced by Mitchell, Oslin, and Griffin (2013) was used for scoring game performance by counting the number of appropriate/effective (1 point) and inappropriate/ineffective responses (0 point). The tally scoring method is applicable to relatively slow striking or track/field games such as baseball or shotput. Also, it is useful for games where there are breaks between game plays but there are lots of observable behaviors such as badminton games. Video recordings were used because there are more than one observable components at a time during the fast badminton game plays.

In this study, as Mitchell et al. (2013) suggested, the game components were measured as the number of appropriate behaviors made divided by the number of sums of appropriate and inappropriate behaviors made (e.g., SE index = A/(A+IA)). This was a useful method to review a player's score because the score always ranges between 0 and 1. Also the scores were easily transferred a percentage by being multiplied by 100. Based on the scores from each game component, a general game play index (i.e., game performance – GP) was determined as a measure of a player's improvement during games. GP index was calculated as the sum of each game component score together divided by the actual number of components detected. There are three components in the study (SE index, DM index, and BA index). The following are the GPAI outcome variables for badminton in this study:

1. Skill Execution Index (SE) = A/(A+IA)
2. Decision Making Index (DM) = A/(A+IA)
3. Base Index (BA) = A/(A+IA)
4. Game Performance (GP) = (SE + DM + BA)/3

* A = Appropriate, IA = Inappropriate

Opportunity to respond (OTR) observation instrument. OTR in physical education is a concept defined as contexts that provide students with opportunities to make relevant learning responses (Brown, 1986; Dugas, 1983; Parker, 1984). The underlying premise of the OTR is that the more students get opportunities to practice skills at an acceptable level, the more they will learn. Therefore, OTR has the following primary objectives: (a) to determine the total number of opportunities students' response was made and (b) the functional effects of the performance with two conditions in terms of successful and acceptable OTRs (Greenwood, Delquadri, & Hall, 1984). Successfulness was based on whether a student hit a shuttle over the net and the shuttle landed within the court, while acceptable trial was based on whether or not a student executed the badminton shot using critical elements. In this study, the rate of successful/unsuccessful, acceptable/unacceptable skill trials, the combinations were measured (for definitions of the four possible coding categories, see Appendix V).

The OTR instrument was used previously in volleyball, soccer, and softball but not in badminton (Brown, 1986; Lawless, 1984; Parker, 1984; Ward, Crouch, & Patrick, 1998). Parker (1984) contended that games could be modified to increase the number of students' OTRs, thus their skill acquisition and game performance would also increase. In this study, the singles play was modified for students to rotate during the game play to maximize students' participation and to prevent low-skilled students from being restricted to being on the sideline for extended periods of time. Appendix V includes the game modification for the rotating system, modified OTR coding sheet, and the percentage of the different types of trials that were calculated in the current study.

Table 4

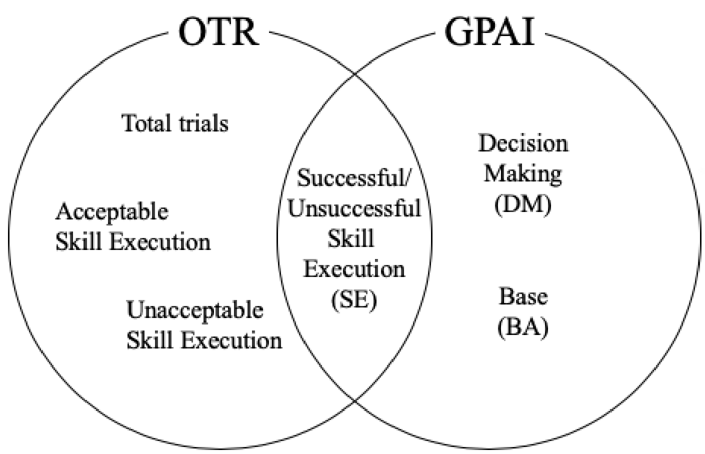
Defined Acceptability and Success for Skill Execution

Skill Execution	Exceeds – 1 point	Struggles – 0 point
Acceptable/ Unacceptable (van der Mars & Harvey, 2010)	• Uses a variety of shots at an episode during game play (e.g., forehand, backhand, clear, drop, and smash). • Uses serve as an attacking weapon with variance in placement and speed.	• Shots only sometimes result in maintaining rally. • Points scored are mostly a result of unforced errors. • Favors mostly one shot (e.g., forehand) regardless of game situation. • Still focused mostly on cooperative rallying.
Successful/ Unsuccessful (Parker, 1984)	• The served shuttle traveled over the net initiating the potential for game play. The shuttle either contacted the floor within the boundaries or was hit by an opponent	• The served shuttle did not travel over the net. • The shuttle contacted the floor outside the boundaries.

Siedentop et al. (2020) presented an authentic assessment tool for racquet game performance. The rubrics provided allow teachers to assess performers' decision making, shot selection/execution/placement, court positioning/court coverage, and anticipation skill, including four scales (exceeds, meets, developing, and struggles) according to a performer's response. The rubric was partially adapted in this study for the tally scoring method. Skills in the rubric were matched with SE. "Exceeds" was applied to "1 point" and "struggles" to "0 point". Table 4 gives an example of how the modified rubrics were used for the tally method in the study. Students' successful skill execution points were also used as a SE index in the GPAI. Figure 10 shows the relationship between the GPAI and OTR.

Figure 10

Relationship between GPAI and OTR instrument



Inter-Observer Agreement (IOA)

In order to evaluate students' game play accurately, the IOA was gained by two trained observers who assessed GPAI. The observers were trained in the first in-person IOA session that included: (a) an explanation of the study; (b) definitions of each component of GPAI, (c) scoring rubrics and methods; and (d) practice with pilot videotapes and live physical education classes. In order to gain the actual IOA rates, the recorded videos were posted on YouTube privately (i.e., people who only know the link address can access to the videos) and shared by first observer. Four more IOA sessions were conducted to obtain the IOA for four indices (i.e., successful skill execution, acceptable skill execution, decision making, and base). Day 4 videos (first formal game play) were randomly selected for the sessions and the observers calculated the GPAI scores (i.e. a hundred badminton shots for each session; two hundred shots for each class) across four indices. The results showed IOA of greater than .90 across the study (see Table 5).

Table 5

Inter-Observer Agreement (%)

Class	IOA			
	Successful Skill Execution	Acceptable Skill Execution	Decision Making	Base
Class A	98.5 (98% - 99%)	95 (93% - 97%)	93.5 (92% - 95%)	94.5 (93% - 96%)
Class B	99.5 (99% - 100%)	94.5 (93% - 96%)	98.5 (98% - 99%)	98 (98%)

Data Analyses

Data from the skill tests and game play videos were analyzed by descriptive and inferential statistics. A 2 (classes) $\times$ 4 (time) Repeated Measures - Analysis of Variance (RM-ANOVA) was used to determine changes in the clear shot execution skill as the result of the interaction between the two variables and time. Main effects and interactions were analyzed, using the .05 level of confidence to test the hypotheses.

A series of 2 (class) × 3 (time) mixed ANOVAs were conducted on the following target game play performance behaviors : (a) Overall GPAI mean scores, (b) successful skill execution (SE-S) component of the GPAI, (c) acceptable skill execution (SE-A) component of the OTR instrument, (d) DM component of the GPAI, and (e) BA component of the GPAI. Since each team had their duty team role, overall GPAI scores were not measured by first and last day of formal competition, but each student's first and last day of game play.

Results

Fidelity of Treatment

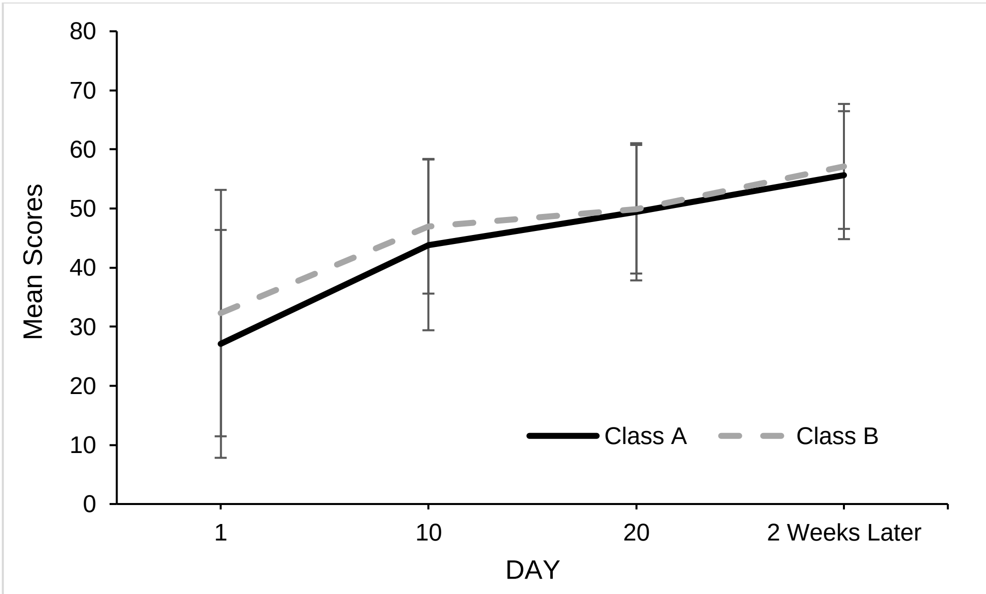
Use of the *Hudl Technique* mobile App was assessed to ensure that the intervention was employed as planned. In Class A, the physical education teacher created a total of 293 videos throughout the season. Of those, 19.79% of voice recordings were made by the teacher and shown to students who had been recorded on video. In Class B, the students created a total of 197 videos. Of those, 18.27% of voice recordings were made by students and seen by students who had been recorded.

Overhead Clear Shot Skill Test Performance

Two students transferred during the intervention, and seven students who were absent more than once were not included in RM-ANOVA data analysis. Figure 11 provides a graphic representation of student performance on *Poole Forehand Clear Test*.

Figure 11

Students' Performance on Poole Forehand Clear Test across the Season.



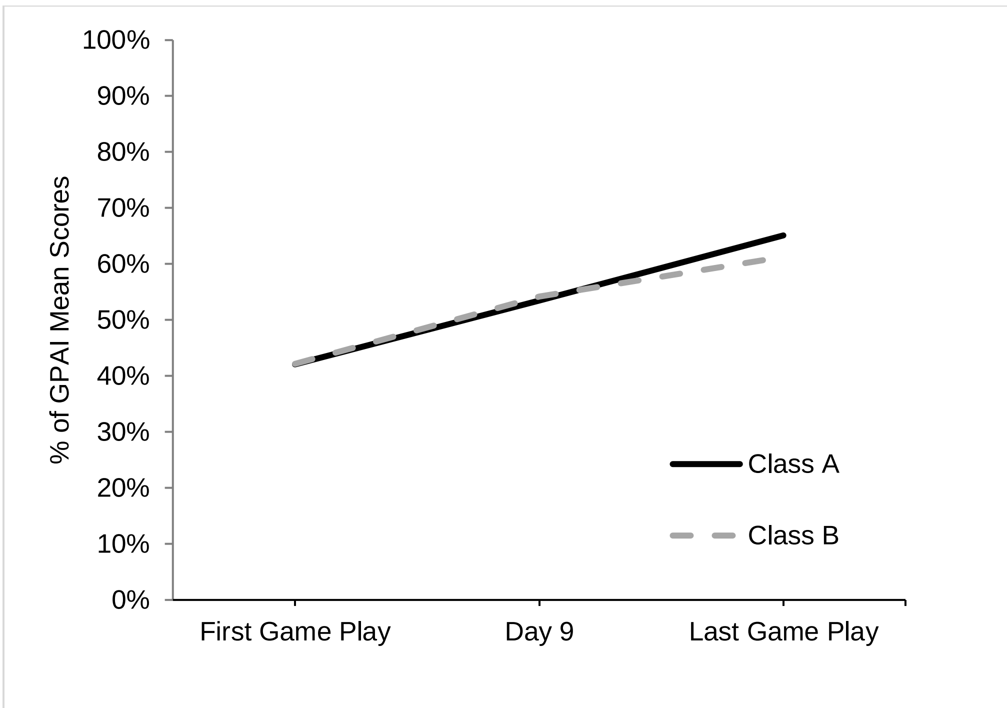
A RM-ANOVA with a Greenhouse-Geisser correction determined that mean scores for the skill tests differed statistically significantly across the four time points (F[1,34]=61.516, p< 0.001). Specifically, paired samples t-tests between each skill test revealed that the mean scores for the skill test produced a slight increase from Day 10 to Day 20 (Mean difference in Class A: 5.6; Class B: 2.9), which was not statistically significant. However, the mean scores for the skill test increased from Day 1 to Day 10 (Mean difference in Class A: 16.8; Class B: 14.7) and from Day 20 to 'Two week Later' (Mean difference in Class A: 6.2; Class B: 7.3), which were statistically significant, respectively.

Game Play Performance

Overall GPAI. Overall, students' average percentages of GPAI scores in both classes significantly increased during the students' formal competition (Class A = 23.04%; Class B = 19.11%). The analysis revealed a main effect of the App use on students' GPAI (F[1,34]=85.702, p < .001). Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated ($\chi^2(2)=1.927$, $p=.382$). In addition to the significant time main effect (with non-significant interaction effect), there was no significant difference in GPAI mean scores between the two classes throughout the season ($F[1,34] = 0.109$, $p > .05$). Figure 12 shows the changes in GPAI score in both classes.

Figure 12

Percentages of GPAI Scores Throughout the Formal Competition in Badminton Season.



For the SEI, there was a significant time main effect ($F[1,34] = 50.952$, $p < .001$), but no interaction effect was evident. There was no significant difference in SEI between the two classes ($F[1,34] = 0.182$, $p > .05$). With regard to the DMI, a significant improvement in both classes was found with no interaction effect ($F[1,34] = 47.124$, $p < .001$), but no significant difference in DMI between the two classes ($F[1,34] = 0.018$, p

> .05). With respect to the BAI, there was a significant time main effect (F[1,34] = 72.010, $p < .001$), but no interaction effect was evident (F[1,34] = 0.263, $p > .05$). There was no significant difference in BAI between two classes.

Figure 13

Percentages of SE scores Throughout the Formal Competition in Badminton Season.

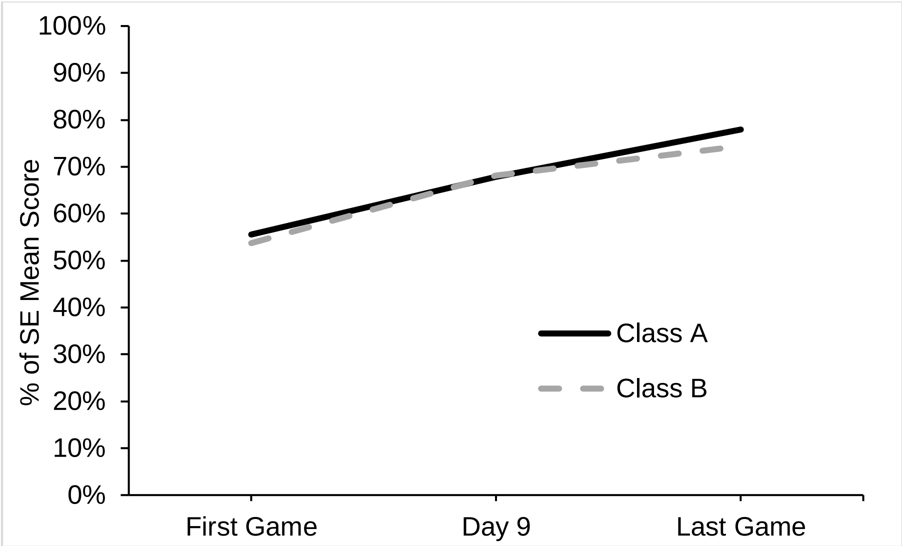


Figure 14

Percentages of DM Scores Throughout the Formal Competition in Badminton Season.

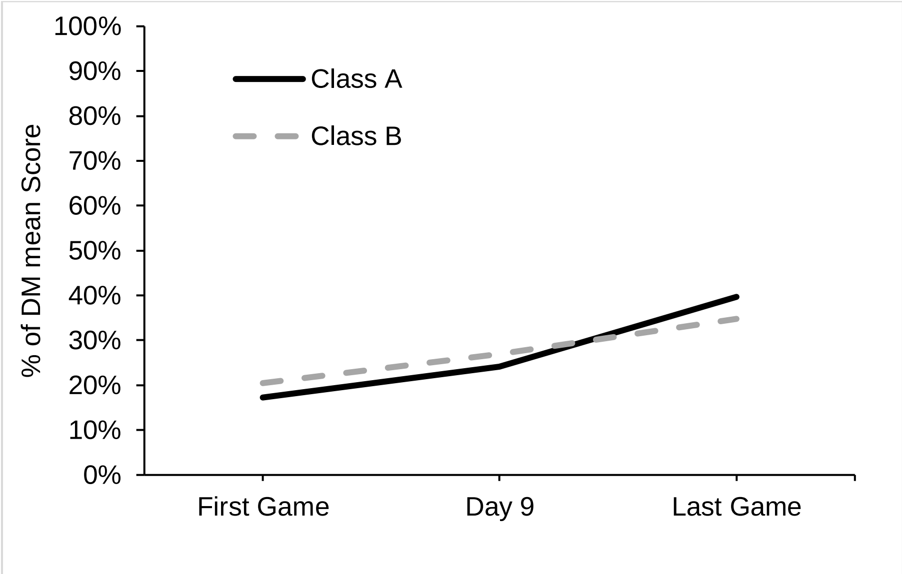
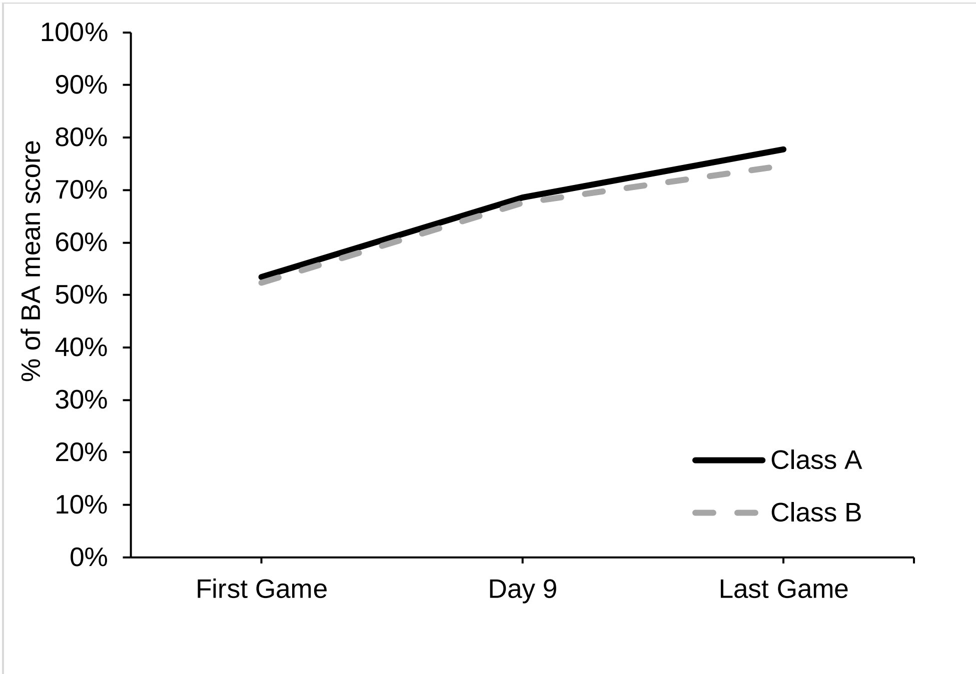


Figure 15

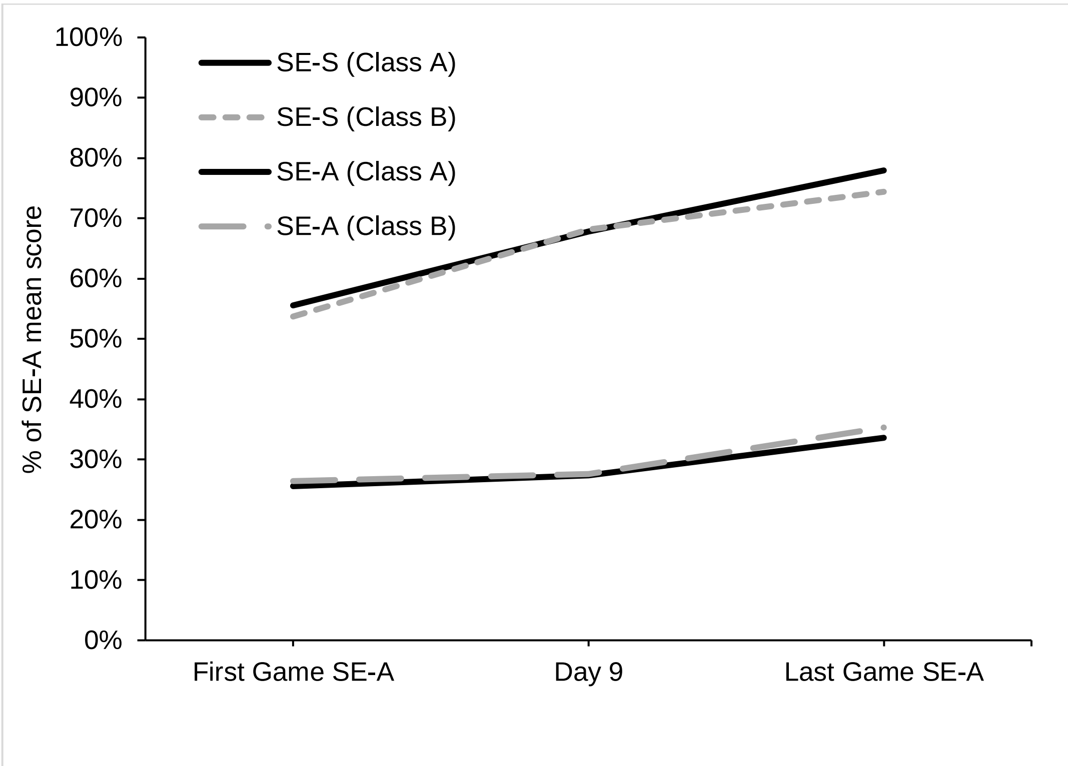
Percentages of BA Scores Throughout the Formal Competition in Badminton Season.



Students' opportunity to respond. The acceptable skill execution components were measured using the same method as the GPAI data to specifically determine the students' skill development. The percentages of the acceptable skill execution for each class were combined with the percentages of the successful skill execution using OTR system. As a result, in both classes, there were increases in the percentages of the acceptable skill execution between the beginning (Class A = 25.57%; Class B = 26.41%), Day 9 (Class A = 27.39%; Class B = 27.56%), and the end of the season (Class A = 33.59%; Class B = 35.30%). However, students in both groups still remained at low-level of acceptable SE. The analysis indicates a main effect of the App use (F[1,34] = 11.314, p = .002), but no significant difference between two groups (F[1,34] = 0.096, p > .05).

Figure 16

Percentages of Successful (SE-S) and Acceptable Skill Performance (SE-A) Scores throughout the Formal Competition in Badminton Unit



Opportunity to respond by skill levels. Four students' accumulative numbers of shot trials and OTR performance rates in each class were counted throughout the season (Figures 17-18). The Figures indicate that high-skilled students had more opportunities to respond than low-skilled students while they are playing games. The data in Table 6 support this result that high-skilled students' average numbers of shots per each rally and total numbers of rallies were higher than low-skilled students in both classes, suggesting that high-skilled students paid more attention while playing games. In addition, Appendix VII shows students' trends on the four OTR behaviors across the season (e.g., successful/acceptable, successful/unacceptable, unsuccessful/acceptable, and unsuccessful/unacceptable). The results indicate that high-skilled students had higher successful and acceptable performances during the games and lower unsuccessful and unacceptable performances than low-skilled students in both classes.

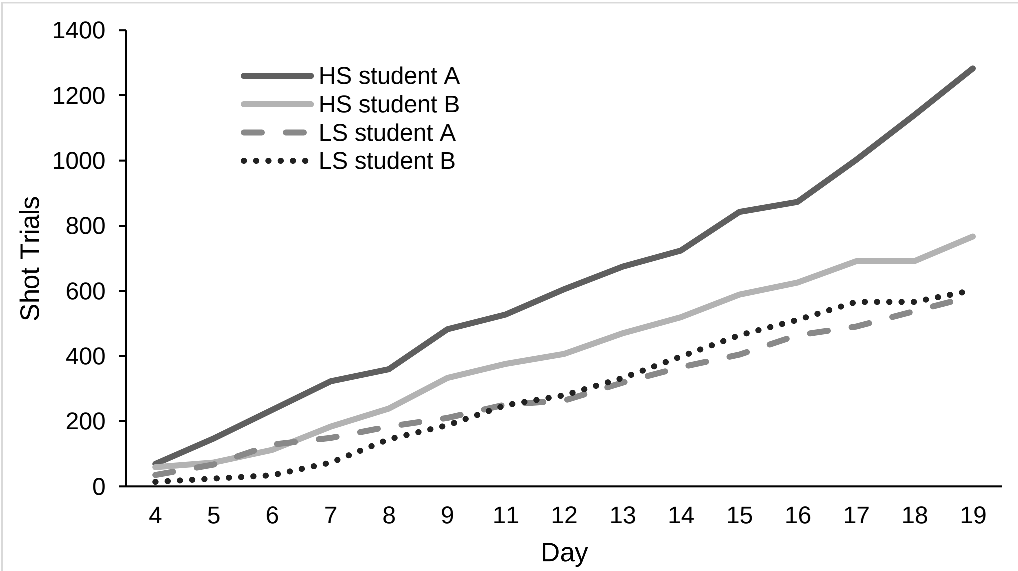
Table 6

Mean Number of Shots per a Rally and the Total Number of Rallies

Class	Student	Mean of Shots per Rally	Total Number of Rallies
Class A	High-Skilled Student A	5.81	415
	High-Skilled Student B	4.29	328
	Mean	**5.05**	**371.5**
	Low-Skilled Student A	4.38	235
	Low-Skilled Student B	3.83	275
	Mean	**4.11**	**255**
Class B	High-Skilled Student A	4.66	404
	High-Skilled Student B	3.90	481
	Mean	**4.28**	**442.5**
	Low-Skilled Student A	3.68	328
	Low-Skilled Student B	3.33	392
	Mean	**3.51**	**360**

Figure 17

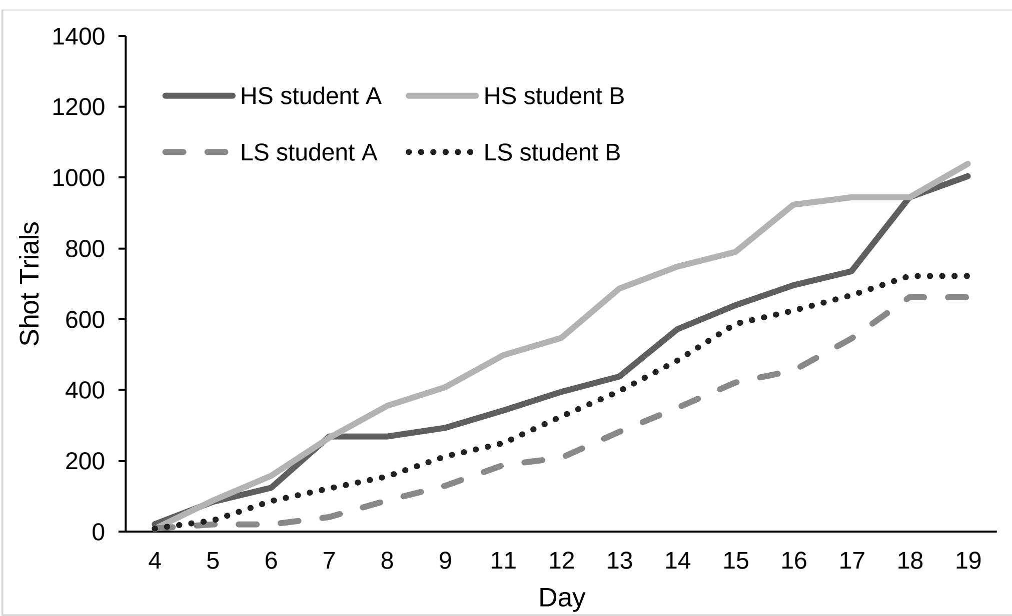
Cumulative Shot Trials throughout the Season in Class A



Note. HS = High-Skilled, LS = Low-Skilled

Figure 18

Cumulative Shot Trials throughout the Season in Class B



Note. HS = High-Skilled, LS = Low-Skilled

Discussion

This study examined the effectiveness of the use of the motion analysis App on students' skill development and several aspects of game play performance. Students in both classes, regardless of the App-use condition (i.e., teacher vs students) improved in their clear shot skill and tactical dimensions of their game performance (e.g., skill execution, decision-making, and base position). It is important to note that, since this study was the first research on the use of Apps in regular physical education settings, it is difficult to tie it back to previous research findings. However, framed within the behavioral ecological model (Hovell et al., 2009), one can infer that using the *Hudl Technique* App in a typical school setting has the potential to positively impact students' motor performance (i.e., badminton skill execution and game performance).

While there is no prior research that mirrors the current study, the findings reported here align with the work by Hastie, Sinelnikov, and Guarino (2009) who reported improvements in badminton in a similar context. Hastie et al. (2009) used a different skill test (wall volley test), yet overall students' skill improvements showed a very similar upward trend, which implies that this study could also support Sport Education-based skill performance and game play performance research. Compared to the study of Hastie et al. (2009), in this study, students' skill test scores increased more dramatically between Day 1 and Day 10. This suggests that the App can be used effectively for developing students' badminton skills even early on in a season while they are learning serving and basic shot skills.

Extended length of season in the SEM allowed adequate time for students to learn skills through the App as well as transfer the skills to the game play context. There is comparable evidence that students improved in both skill execution and game play during a 6-week intervention (French et al., 1996). The similar length of the intervention in this study supports their findings with similar claim that students need time to develop skillful game play.

The SE scores were directly related to the improved GPAI scores, providing further evidence that learners in a SEM context can move toward building competence in badminton over the course of a 14-lesson season (Siedentop et al., 2020). However, compared to the successful skill execution, the appropriate skill performance rates remained low. These low rates were mainly based on the low rates of appropriate backhand shots and, regardless of skill levels, most of students had a hard time using appropriate backhand shots until the end of the badminton season. Therefore, it is important to develop and validate a new instrument to measure students' backhand shot skill execution.

The video rewind using the App was an effective way of reviewing students' movement (i.e., decision-making and base) during rallies. According to the research field notes, the Physical Education teacher's overall skill instruction through the App was ended by Day 7, the teacher started focusing on aspects such as footwork, decision making, and court coverage from Day 8. Figure 14 shows the result of the instructional change. However, while the average percentages in SE and BA index were over 50% from the first day of the season, the percentage of DM index remained under 50% throughout the season. In this respect, it is suggested that, as an important strategy for the next level of game play, there is a need for helping students focus on analyzing their skill movement and explaining their decisions to solve technical and tactical problems from the first lesson that students use the App (Blomqvist, Luhtanen, Laakso, & Keskinen, 2000).

This was the first study in which the use of a digital motion App was the main focus, which means that the ways of students' learning were different from the ways without using the App. Consequently, the time that the students are physically active is inversely proportional to the time using the motion analysis App. Therefore, innovative ways of using the App (e.g. accumulative digital data logs after video analyses) are needed to increase the benefits from the App feedback in the time available while students use it during team practice, and game play as well.

The smaller number of recordings students made in Class B shows the evidence that students took some time to learn how to use the App and how to analyze their motions at the same time. According to the recordings from the students, they were just describing their movements in the videos instead of analyzing the motions for the first few days of the season, compared to the teacher. The teacher's instruction with technology was different from traditional teaching styles, implying that the use of technology had the potential to impact student learning in various unique ways. In this study, in addition to the benefits from the immediate visual feedback the *Hudl Technique* provided students with, the features of screen split and screen overlay effects have the potential to become more useful and effective when the general use of the App has become a second nature (i.e., students become more skilled in using the basic aspects of the App). Therefore, the lesson plans should be updated when the instruction includes technologies. The teacher also changed the way in which he used the App from reviewing skills to strategies. Considering the teacher had little experience with the App, it is assumed that the teacher was able to gradually gain his own technological pedagogical skills using the App when he observed and analyzed students' game play.

Even though students' skill test and maximum game play participation were the benefit from the intervention, it was evident that there were no significant differences on skill and game performance between two classes. Therefore, further study will be needed with a control class that does not use the *Hudl* to better understand the added value of using the App. Furthermore, given that the effectiveness of the use of the *Hudl* may vary depending on a teacher's instruction, types of sports, or curricular models, further research using the App is necessary to determine students' skill and game competences during a variety of contexts such as different populations at other schools with different sports.

Conclusion

Within the limitations and design of this study, the following conclusions are warranted. First, the use of a motion analysis App can contribute to improvements in selected aspects of badminton skill and game play performance in a middle school Sport Education season context. Second, the teacher was able to learn different instructional skills by using App technology. And third, the App provided students with the video-based instant feedback to review and improve their own skill execution and game play.

CHAPTER 4

PHYSICAL EDUCATION TEACHER AND STUDENTS' PERCEPTIONS OF USING DIGITAL TECHNOLOGY (MOTION ANALYSIS APP)

The Society of Health and Physical Educators (SHAPE America, 2014) established the "Grade-Level Outcomes for K-12 Physical Education" relevant to technology to promote students' physical activity (PA) involvement and self-monitoring (including S3.M4.6: Participates in a variety of aerobic-fitness activities using technology such as Dance Dance Revolution or Wii Fit; S3.H2.L2: Analyzes and applies technology and social media as tools for supporting a healthy, active lifestyle; S3.M8.8: Uses available technology to self-monitor quantity of exercise needed for a minimal health standard and/or optimal functioning based on current fitness level; S3.H10.L2: Adjusts pacing to keep heart rate in the target zone, using available technology, to self-monitor aerobic intensity). These intended outcomes have resulted in changes in Physical Education Teacher Education (PETE) programs to integrate technology into the programs (Jones, Baek, & Wyant, 2017) and a variety of ideas have been proposed in the professional literature to provide in-service teachers with opportunities to enhance their pedagogical experiences with technology (e.g., Mobile applications to motivate students to move, video recording as an aid to formative assessments, web-enabled tablets as a tool for teaching, and digital movement analysis software for feedback and assessment) (e.g., Baert, 2015; Martin, Melnyk, & Zimmerman, 2015; Leight, Banville, & Polifko, 2009; Phillips, Rodenbeck, & Clegg, 2014; Rosenthal & Eliason, 2015; Sinelnikov, 2012; Trout, 2013).

According to Barron, Orwig, Ivers, and Lilavois (2001), technology has the potential to provide teachers with an added avenue for instruction within a multi-sensory diverse learning environment. Barron et al. (2001) stated the benefits from technology integration in education: (a) promoting active learning/critical thinking/cooperative learning, (b) offering diverse and self-paced learning/individual growth, (c) inspiring students by making exciting learning environments, (d) increasing teacher-student interaction and communication skills, and (f) supporting students with diverse learning style (p. 3-8). There is a growing body of literature, in which it is suggested that students benefit in various ways in their classes where digital video was integrated, such as motivation, enjoyment, and learning (Hoffenberg & Handler, 2001; Koekoek, van der Kamp, Walinga, & van Hilvoorde, 2019; Koekoek, van der Mars, van der Kamp, Walinga, & van Hilvoorde, 2018; Palao et al., 2015; Weir & Connor, 2009).

Schwartz and Hartman (2007) introduced a model for learning with digital video to consider a relationship between video and learning. Figure 19 shows different classes of learning outcomes. The first ring indicates four learning outcomes that might aim to different learning targets (second ring). '*Seeing*' refers to the signature ability of video that helps students catch moments they could not see before or overlooked. Approaches to '*Engaging*' is to raise students' interests and to contextualize information in meaningful ways to learners. Video is ideal for '*Doing'* outcomes to present human behavior. '*Doing*' involves attitude/modeling (unintentional) and skill acquisition (intentional effort and practice). 'Saying' involves the acquisition of fact and explanation. The third ring shows the assessments, which are the different types of behaviors where students can exhibit what they have learned. This phase will help verify the meaning of the learning outcomes and specific learning targets. The last (outside) ring refines several samples of video genres for the four outcomes.

Figure 19

Model for Learning with Digital Video (Schwartz & Hartman, 2007)

With regard to Physical Education, traditional types of digital technology have been used in schools for recording students' motor skill performance (Hastie, Calderón, Rolim, & Guarino, 2013). Learning in the psycho-motor domain is one of the main intended learning areas in physical education. There is evidence that technology (i.e., video) has been useful to measure a skill execution and provide immediate feedback to students (Hastie, 1998; Hastie et al., 2013). In the recent past, video was saved as digital data and edited only on a computer, which can be one of teachers' barriers to instructions using video due to the time issues. The recent advance of digital devices has enabled teachers to use more compact, cheaper, and portable cameras that provide much improved quality in their instructions. Today, mobile application (App) technology enables teachers to record and edit simultaneously with their smartphones or tablets even while teaching. Baert (2015) gave examples of video technology applications (e.g., mobile devices) into teaching to accomplish the national standards such as creating open space (S2.M7.6) and returning to a midcourt position (S2.M8.6) in a net/wall unit (SHAPE America, 2014).

Domingo and Garganté (2016) found various impacts on learning with mobile technology from previous research: (a) providing new ways to learn, (b) increasing engagement to learning, (c) promoting autonomous learning, (d) facilitating access to information, and (e) promoting collaborative learning. However, there is little evidence to date that the use of App technology by physical educators results in students' improved learning. Therefore, it is crucial to evaluate teachers' and students' views of the integration of the video technology using Apps in their instruction to help students learn.

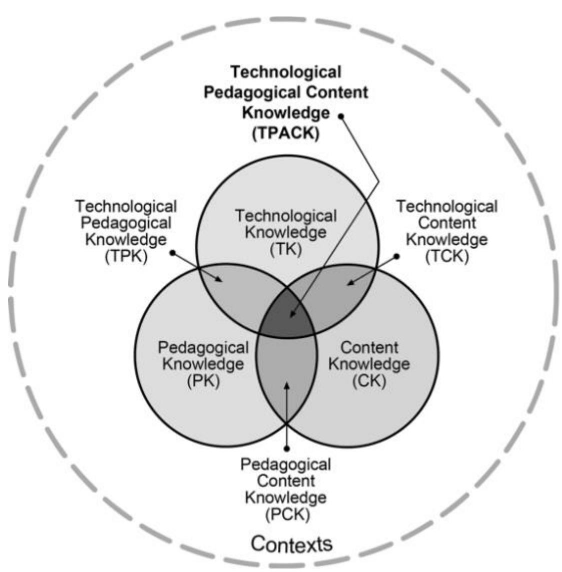
In spite of the usability and potential benefits of technology-integrated pedagogy to enhance student learning, instructional practice, and overcoming pedagogical challenges (Casey, Goodyear, & Armour, 2016), research on the use of digital video technology in physical education is still limited (Kretschmann, 2015). This may be due to the constraints of technology use in physical education such as time needed for preparation and teachers' insufficient technology competencies (Hew & Brush, 2007; Palao, Hastie, Cruz, & Ortega, 2015). Baek, Jones, Bulger, and Taliaferro (2018) found teachers' challenges in integrating technology in physical education. External obstacles included lack of access to technologies, budget, insufficient time to learn technological skills, inadequate technical and administrative support, and class size. Internal factors included teachers' pedagogical beliefs and attitudes, knowledge, skills, and self-efficacy (Baek et al., 2018, p.176).

Hew and Brush (2007) reported strategies to overcome barriers/obstacles of technology integration from previous research: (a) having a shared vision and technology integration plan, (b) overcoming the scarcity of resources, (c) changing attitudes and beliefs, (d) conducting professional development, and (e) reconsidering assessments (p. 232). As the third strategy provided by Hew and Brush (2007) above, it is evident that the successful infusion of technology relies on teachers' attitudes and beliefs such as their self-confidence, self-efficacy, and their willingness to change pedagogical strategies (Vannatta & Fordham, 2004; Watson, 2006). Teachers' positive views of technology were related to their opportunities for employing different types of technologies, which means that if teachers receive adequate training and support in technology, they are more likely to try it out in their teaching (Crowe & van 't Hooft, 2006; Keiper, Harwood, & Larson, 2000; Mason & Berson, 2000).

Shulman (1987) discussed an array of knowledge that teachers should be equipped with: (a) content knowledge (CK), (b) general pedagogical knowledge (PK), (c) curriculum knowledge, (d) pedagogical content knowledge (PCK), (e) knowledge of learners and their characteristics, (f) knowledge of educational context, and (g) knowledge of educational ends, purposes, value, philosophical and historical grounds. Among those categories, the pedagogical knowledge was represented as distinctive body of knowledge of teaching. He defined PCK that "It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction (p. 8). Koehler and Mishra (2009) enhanced Shulman's framework of pedagogical content knowledge. They viewed technology as a separate domain of knowledge that is acquired by teachers along with the content knowledge and pedagogical knowledge. As shown in Figure 20, technology is embedded in every aspect of teaching, meaning that appropriate or inappropriate use of technology can affect teaching and learning. Therefore, it is important to investigate the relationships that arise between these complex knowledge systems. Technological pedagogical content knowledge (TPACK) in Figure 20 encompasses all three domains (content, pedagogy, and technology). Koehler and Mishra (2009) insists that TPACK represents pedagogical techniques using technologies in innovative ways to teach certain content.

Figure 20

Application of Technological Pedagogical Content Knowledge framework



The use of technology had a positive influence on student engagement in physical education (Casey & Jones, 2011; Hastie, Casey, & Tarter, 2010; Rossing, Miller, Cecil, & Stamper, 2012). Casey and Jones (2011) investigated the effectiveness of video-analysis software on motor skill development (i.e., throwing and catching skills) with low-skilled and disengaged students. The video technology had a significant influence on student engagement and learning in physical education classes. The technology was also helpful for students' self-appreciation of skills, articulation of what they understood, and a transfer of activity practices. Rossing et al. (2012) conducted a study to identify collegiate students' perceptions of incorporating mobile technology in learning environments at Indiana University – Purdue University Indianapolis (IUPUI). Instructors in seven departments (i.e., Music, Communication Studies, Tourism Management, Physical Education, English, Organizational Leadership and Supervision, and Library Science) took part in the study to measure students' perceptions of iPad usage. The physical education instructor used a video analysis App to measure human movements. Overall, across participants, students' perceptions were positive especially in connecting ideas in new ways, that is, participating in course activities in ways that enhanced learning, and where they were able to apply course content to solve problems. However, there was no evidence collected on the actual impact on student learning and the study did not specify students' perceptions about using technology by type of course or the specific feedback for Physical Education.

Despite the broad support in the professional literature on the potential of digital technologies to enhance student learning, there remains a dearth of evidence on the actual impact on student learning, especially within the context of physical education.

Therefore, the purpose of this study was to assess both a teacher's and his students' perceptions of digital video technology (a motion analysis mobile application) used in physical education classes. These stakeholders' experiences in the study are important for developing a deeper understanding of the effectiveness and the role of mobile video technologies on students' motor skill development in physical education. The specific research questions were as follows:

1. What are the teacher's perceptions of using a motion analysis mobile App (advanced video technology) as part of regular daily instruction during a middle school badminton season?
2. What are the students' perceptions and experiences with using a motion analysis mobile App (advanced video technology) during a middle school badminton season?

Methods

Participants and School Setting

The participants were recruited from two randomly assigned eighth grade classes from one charter school in the southwestern US. There were 1,150 students at the school (64.7% Caucasian, 19.2% Hispanic, African American 5.2%, and 0.6% American Indian/Pacific Islander), with 19.5% of students eligible for free/discounted lunch. Gender ratio was almost equal.

The physical education teacher (male, Caucasian) in the school has taught middle school students over seven years, and currently implements a variety of sports using the Sport Education curricular model (Siedentop, Hastie, & van der Mars, 2019). Previously, he had taught Sport Education seasons for softball, volleyball, basketball, badminton, flag football, ultimate frisbee, and track and field.

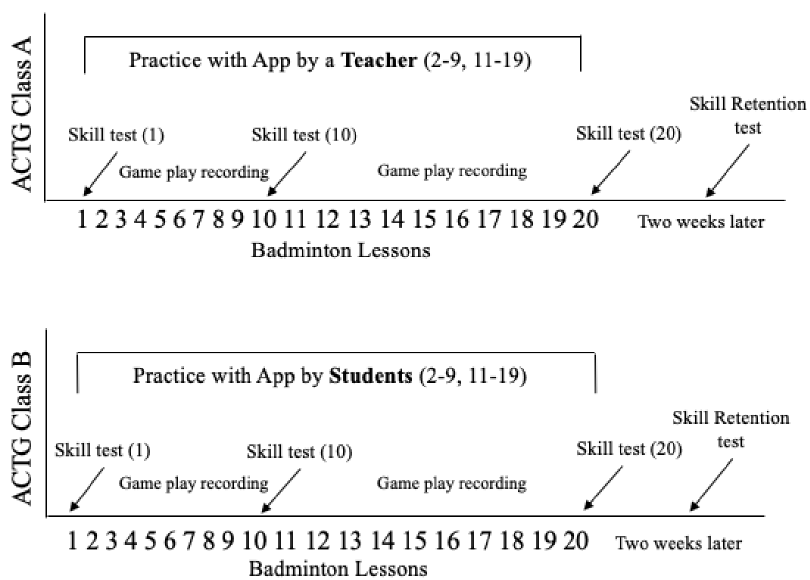
The school had adequate physical activity facilities and equipment for this study including four indoor badminton courts and outdoor grass fields. Fifty full time teachers were currently employed at the school, with a 23:1 student-to-teacher ratio. One hundred percent of full-time teachers were certified and 68% of teachers had three or more years of experience. Overall, the school performed more than 20% above average on State standardized tests in English, Mathematics, and Science.

Study Research Design

The primary researcher and one physical education teacher developed a 20-lesson Sport Education-based badminton season plan together taking the school context and setting into consideration.

Figure 21

Alternative Control Treatment Group Research Design

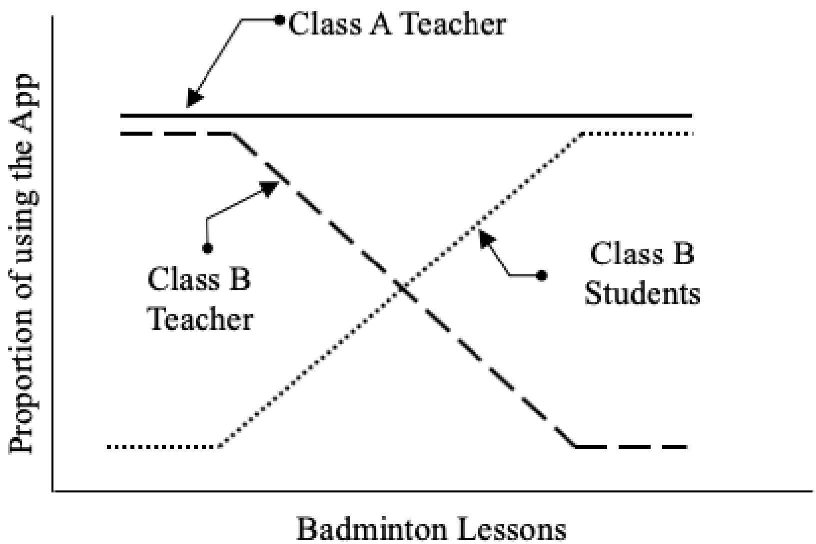


This study is part of larger study that investigated the effectiveness of the use of digital video technology using mobile devices in physical education classes. As shown in Figure 21, the research design used was the Alternative Control Treatment Group (ACTG) research design (Borg, 1984) with two intervention classes (Class A: the teacher employing the *Hudl Technique* App; Class B: use of the App by students) was used to determine if it improved students' skill execution and tactical game play. The main purpose of applying this research design was to provide all students in this study with benefits from the intervention and to rule out five threats of internal validity, as Borg (1984) insisted (i.e., experimental mortality, diffusion or imitation of treatment, compensatory equalization of treatments by providing control group with benefits from other sources, compensatory rivalry by respondent receiving less desirable treatment, and resentful demoralization of respondent receiving less desirable treatment).

The physical education teacher was trained by the research team in how to employ the motion analysis mobile App (i.e., *Hudl Technique*) in his teaching a week before the badminton season started. From Lesson 2, the teacher taught Class A by using *Hudl Technique*. In Class B, the physical education teacher instructed the students on the use of motion analysis App using iPad-minis®, and let students have responsibility for using it within their teams. Figure 22 shows the proportion of the use of mobile App between the teacher and students. Students in the two classes received regular (non-)verbal skill feedback and prompts from the teacher or peers as well as opportunities for feedback through the use of the motion analysis App. They took clear shot tests during Lesson 1, 10, 20 and two weeks later. During the game play, students within the same team were rotating every time they lost or won twice in the rallies to promote all students' maximum participation and prevent one student's domination of game play.

Figure 22

The Ratio of Using Mobile App between a Teacher and Students



Introduction of Motion analysis mobile application (Hudl Technique)

Hudl Technique App is a useful slow-motion video analysis application that allow a teacher to provide students with immediate feedback on their skill execution. The App has three functions that were used in the intervention: (a) adjustable slow motion speed (1/8, 1/4, or 1/2), (b) a zoom function that helped the teacher to examine specific skill movements such as foot work or wrist action in badminton, (c) a drawing tools with recorder that allowed students to record peers' techniques and give instant feedback during practices and games, highlighting students' motion with different lines and shapes on the videos.

The lead researcher and the physical education teacher met five times to discuss intervention planning (i.e., checking out the equipment, court placement and lining, etc.). In the meantime, the teacher was trained to administer a skill test. The training also included: (a) a review of the planned content, format and organizational procedures for the badminton season, (b) Clear shot skill test protocol, (c) use of *Hudl Technique*.

The researcher and teacher decided the length of the season and shared the detailed lesson plans. Two students who were not involved in the study were invited by the teacher to practice clear shot skill test. Sample videos from the practice and the pilot study were used to plan how to use the *Hudl Technique*. The teacher tried out the basic features of the App (e.g., video slow motion in different speeds, drawing tools, and voice recording while reviewing the original video) during the volleyball season before the badminton intervention.

In Class B, students were introduced to the use of *Hudl Technique* starting on Season Day 2. The teacher explained the App features and how to use them to the whole class and each team started using the App with an iPad mini during their team practices. While two students were playing, the rest of team members were asked to record videos and analyze peer's skills and game performances. They used the voice recording feature in the App when reviewing videos.

Data Collection

For this study, the following data sources were used: a) the critical incidents instrument completed by students (Flanagan, 1954), b) one semi-structured interview with the teacher prior to and one following the badminton season, and c) daily reflection interviews with the teacher throughout the season. This allowed the researcher to capture the stakeholders' perceptions of the video technology intervention in the badminton season.

Critical incidents. The critical incident technique (Flanagan, 1954) was used to investigate the aspects of the '*Hudl Technique*' that the student participants thought as significant during 20-lesson badminton season. At the conclusion of five lessons throughout the season, students completed a critical incident reflection sheet that had similar instructions to those used by Hastie and Curtner-Smith (2006). They were asked to write on two topics: (a) "Your experiences of the Motion Analysis App (if you had). How did you feel about using the App? (for example, what did you see from the App or what feedback did you get from your teacher or what feedback did you give your classmates using the video clips?) When you have described what happened, try to explain why it was important.", and (b) One thing that happened during your lesson today or this week that you found important. It may have been important because it made you excited, made you bored, made you worried, or because it was something you learned that was really new. When you have described what happened, try to explain why it was important".

Pre- and post-intervention semi-structured interview with the teacher. For the purpose of this study, an interview protocol was developed based on previous research on teachers' perception of technology integration (Baek et al., 2018; Domingo & Garganté, 2016; Holland, 2001). The purpose of this pre-intervention interview was to gauge the teacher's overall interest, perception of technology, and whether/how video technology might help him in his teaching. The interview was audio-recorded. Preliminary questions focused on his understanding of the Sport Education model, and his perceptions about students' skill levels. This was then followed by questions focused on his thoughts on the adoption of technology in general and *Hudl Technique* training in particular, as well as his developmental level in using technology in his physical education program. The latter questions were based on the developmental levels in technology use proposed by Holland (2001). The teacher rated his own initial developmental level based on the characteristics in the Table 7.

Table 7

Teachers' Developmental Levels in Technology

Developmental levels	Teachers' characteristics
Non-readiness	Have little interest in technology
	Have little knowledge and skills of technology
	Be resistant to using technology
Survival	Focus on their own learning of technology
	Have limited knowledge and skills of technology
	Need technological supports in their classroom
Mastery	Have knowledge and skills of technology in limited areas
	Need to expand knowledge and use of technology
	Have limited approaches to instructional use of technology
	Need personal assistance rather than formal in-service training
Impact	Integrate technology into teaching and curriculum
	Use technology as an instructional tool
	Have challenges to management for monitoring students
Innovation	Use a variety of technology applications in teaching
	Substantially change ways to teach with technology

Following the completion of the Badminton season, the teacher was again interviewed using a semi-structured format. The teacher's experiences and perceptions about the use of *Hudl Technique* were explored through the post-intervention interview and the interview was also recorded and transcribed by the lead researcher. The interview questions included: (a) the teacher's experiences that were the most influential to you when using the *Hudl Technique*, (b) ways that the use of *Hudl* App impacted students' skill and game play development, (c) (compared to teaching without the *Hudl Technique)* changes in the instruction when using the *Hudl Technique*, (d) the main advantages and disadvantages of the App? (e) reasons whether the teacher wants to continue to use the *Hudl Technique* or not, (f) the more difficult aspect of using Hudl and the reason, and (g) suggestions for other teachers who are considering using it (For a list of interview questions, see Appendix VIII.)

Daily reflection interviews and field notes. The Physical Education teacher also participated in a daily reflective interview after each of the 20 lessons taught to both Class A and B. The teacher briefly reflected on what went well and challenges that arouse after each class. The lead researcher was present for every class session. The teacher's daily reflections were captured by the lead researcher with audio recordings. If needed, the teacher and lead researcher worked together to solve any logistical problems that arose. The researcher also took daily field notes about the process of using video technology for the teacher and the students across both class A and B following each of the 20 lessons.

Data Analysis

Critical incident. Students completed 178 critical incident sheets (one each about every five days). Six major data categories were pre-determined according to the previous study (Hastie & Curtner-Smith, 2006). During the first phase, the ideas for categorization were considered to see if the data collected in the study fit in the pre-determined categories (shown in Table 8). For this study, one major category (*App-related*) was added to the codes.

Two trained reviewers independently reviewed and coded all of the critical incident sheets. After coding, the two reviewers discussed and negotiated any critical incidents that were not coded the same until the consensus was reached. All codes that did not appear in the critical incident sheets were deleted and the codes that had the same aspects in the data set were incorporated into several categories. The critical incident data were sorted into participants' perceptions that were consistently stated with a single idea within the seven major categories. The comments were coded and categorized by using the analytic induction technique (Goetz & LeCompte, 1984). Once the coding process was finished and negotiated by the two coders, the frequency for each code was calculated for each category to identify the students' perceptions from their critical incident comments.

Pre/post-intervention interviews with the teacher and daily reflection. Interview recordings were transcribed verbatim to preserve a record of the meaning of passages by the primary researcher using the '*Otter*' mobile App. For the first phase, a deductive process was used to categorize the raw data themes that were detected from the interview transcriptions. Using the repeated reading method for data immersion (Braun &

Clarke, 2006), the transcriptions were first read five times by the lead researcher. Next, the lead researcher and a second coder both reviewed the transcripts independently to categorize the raw data themes.

The two reviewers negotiated themes until three final overarching themes emerged. Following the identification of the three themes, the researchers assessed the transcriptions by questioning the teacher's answers to make explicit reasons guiding content and thematic data analysis. The researcher and the second coder's interpretation involved reviewing the transcripts to find meaningful and specific segments representing the teacher's experiences. The three data themes generated by the research team provided a detailed sense of data on how and why the teacher's perceptions of the technology integration had changed. As Braun and Clarke (2006) suggested, the thematic map were developed by the lead researcher (Appendix IX) to organize the codes and find connections between them.

Data Trustworthiness

Trustworthiness of critical incident (with second reviewer) and the teacher's daily reflection/interview data (with third reviewer) was established through the use of an audit trail that was kept by three reviewers who independently reviewed all transcripts and member checking with the teacher. The confirmability audit was conducted as a dependability process by asking the physical education teacher if the students' self-reported data sheets, interview recordings/transcripts, and the interpretations (i.e., themes) made by reviewers were internally coherent and represented more than just "figments of the imagination" (Guba & Lincoln, 1989, p. 243). The teacher agreed with the themes and data from the critical incident sheets and interview transcriptions. Further, data triangulation took place by comparing data generated by the interviews, informal interviews, field notes as well as by comparing similarities between the student critical incidence reports and the teacher interview data.

Results

Student-Reported Critical Incidents

Badminton season-related comments. Three hundred and sixty-six perceptions about the badminton season using the App were coded from the critical incident sheets (207 for Class A; 159 for Class B). Six major categories were established from the previous study (Hastie & Curtner-Smith, 2006) and an App-related category was added. Table 8 indicates the seven major categories and 48 sub-categories. Overall, 92.6% of positive comments (339) were found.

In general comments about the badminton season, 28 positive comments were found. Students' expressions about the badminton season in their comments were 'Excited', 'Fun', and 'Enjoyed'. Team affiliation as one of the Sport Education features brought eight positive team-related references (e.g., 'made us go in good league', 'do better as a team', and 'teamwork'). Team play resulted in 15 comments in the 'Affective' category. Nine references indicated that the students encouraged each other, showing efforts and sportspersonship. There were five comments for 'worried' about losing and inexperienced skills.

Students made 49 skill-related comments throughout the season (34 in Class A; 15 in Class B) and 30 comments were found in Day 5 class (20 and 10 comments, respectively). The teacher taught students specific components of basic movement and skills such as ‘good stance’, ‘backhand serving’, ‘form’, ‘grip’, ‘drop shot’ and ‘keeping an eye on the birdie all the time’. Students also produced 82 game-related comments (51 in class A; 31 in Class B). Students focused deeply on employing tactical moves (30 comments) to win (24 comments) such as ‘made the opponent move around the court’ and ‘go to the center after every hit’, rather than complaining about the rotating play system or the number of courts. They also expressed their specific successes (12 comments) such as ‘only missed 2 shots today’, ‘my form and serves went well’, and ‘one that worked very often is hitting close to the net’. The proportion of statements between the App-related and the Other Sub-categories are shown in Figure 23.

Table 8

Frequency of Students’ Perceptions in Critical Incidents

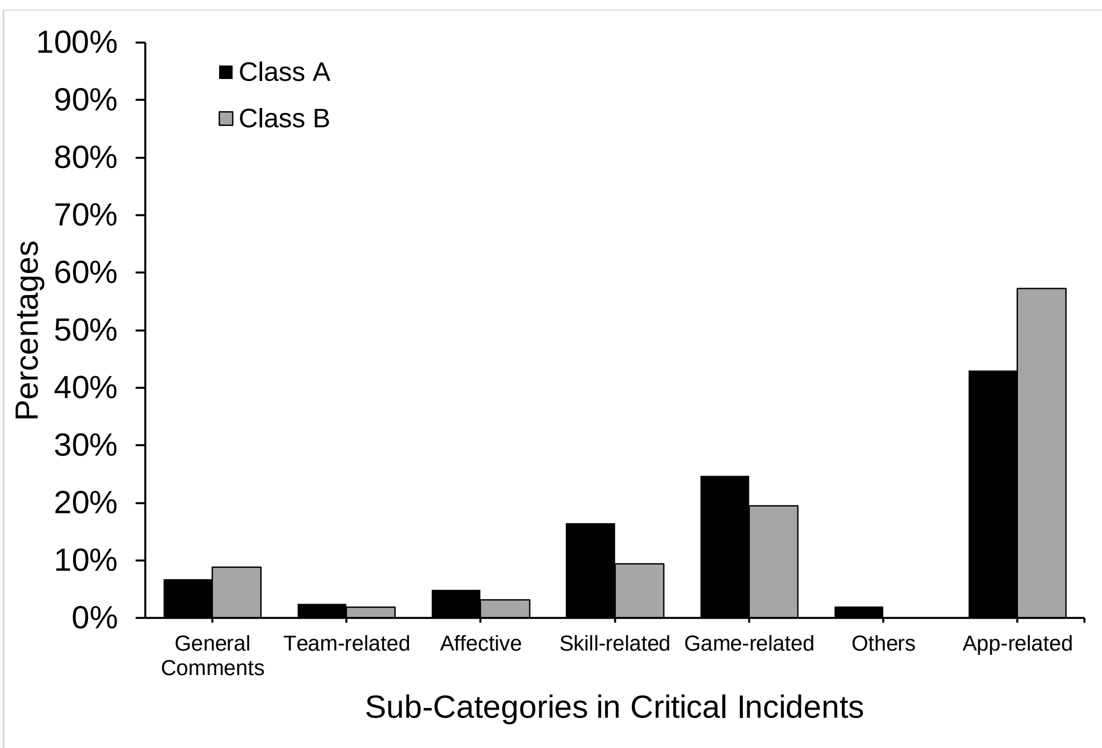
Class	Lesson											
	Day 5		Day 8		Day 11		Day 14		Day 17		Total	
	A	B	A	B	A	B	A	B	A	B	A	B
General comments about lesson												
Enjoyed/ Excited	4	6	0	1	0	1	1	0	4	2	9	10
Fun	0	0	2	0	0	0	0	0	0	1	2	1
Don’t like/annoyed	0	0	0	0	0	1	1	0	0	1	1	2
Tiring/boring	0	1	0	0	0	0	1	0	0	0	1	1
Hard to learn	0	0	1	0	0	0	0	0	0	0	1	0
Subtotal	4	7	3	1	0	2	3	0	4	4	14	14
Team-related												
Teamwork	1	0	1	2	0	1	0	0	0	0	2	3
Affiliation	0	0	1	0	0	0	1	0	1	0	3	0
Subtotal	1	0	2	2	0	1	1	0	1	0	5	3
Affective												
Cool	0	0	2	0	0	0	1	0	1	0	4	0
Worried	1	3	0	0	0	0	0	0	0	1	1	4

Not be Cocky/Salty	1	0	0	0	0	0	0	0	0	0	1	0
Being with friends	1	0	0	0	0	0	0	0	0	0	1	0
Effort	1	0	0	0	0	0	0	0	0	0	1	0
Confident	0	0	1	0	0	0	0	0	0	0	1	0
Fair Play	0	1	0	0	0	0	0	0	0	0	0	1
Encourage pupils	0	0	1	0	0	0	0	0	0	0	1	0
Subtotal	4	4	4	0	0	0	1	0	1	1	10	5
Skill-related												
Enjoy skills	2	0	0	0	0	0	0	0	0	0	2	0
Learning/ Performing skills	18	10	5	1	3	2	4	2	1	0	31	15
No feedback from teacher	0	0	1	0	0	0	0	0	0	0	1	0
Subtotal	20	10	6	1	3	2	4	2	1	0	34	15
Game-related												
Enjoy in general	1	0	0	0	0	0	0	0	0	0	1	0
General success	0	0	0	0	0	0	2	0	0	0	2	0
Specific success	0	0	1	0	4	4	1	2	0	0	6	6
Employing tactics	1	1	4	1	6	2	6	6	3	0	20	10
Specific failure	0	0	0	0	1	0	0	1	0	0	1	1
Winning	4	4	1	0	2	3	4	5	0	1	11	13
Losing	2	1	0	0	2	0	0	0	2	0	6	1
Enjoy because team sport	1	0	0	0	0	0	0	0	0	0	1	0
Rules	1	0	0	0	0	0	0	0	0	0	1	0
Teacher involvement	1	0	0	0	1	0	0	0	0	0	2	0
Subtotal	11	6	6	1	16	9	13	14	5	1	51	31
App-related												
Helpful/effective	0	0	3	5	5	7	2	7	3	7	13	26
Useful	0	0	2	0	2	0	0	0	2	2	6	2
Get more ideas	0	0	0	0	0	0	0	1	0	0	0	1
Excited/fun	0	0	0	0	0	0	0	0	3	1	3	1
Motivated	0	0	0	0	0	0	0	0	1	0	1	0
Good/Cool/Like	0	0	2	4	3	2	3	0	4	3	12	9
Bored/was ok	0	0	0	0	0	0	0	0	1	1	1	1
Don’t like it/worried	0	0	0	0	0	0	1	0	0	1	1	1

Not helpful	0	0	0	0	0	0	0	0	1	1	1	1
Action and motion	0	0	1	1	0	0	0	0	0	0	1	1
Feedback	0	0	2	1	0	1	0	1	0	0	2	3
See myself/team	0	0	7	3	5	4	2	2	5	2	19	11
Fix mistakes in motion (skill)	0	0	5	2	0	1	1	0	2	3	8	6
Tactics with App	0	0	0	0	4	2	2	5	4	4	10	11
Get better/ Improve	0	0	3	6	2	3	3	2	3	6	11	17
Subtotal	0	0	25	22	21	20	14	18	29	31	89	91
Others												
Didn't learn new	0	0	0	0	1	0	1	0	0	0	2	0
Being alert	0	0	1	0	0	0	0	0	0	0	1	0
Injury/Sick	0	0	1	0	0	0	0	0	0	0	1	0
Subtotal	0	0	2	0	1	0	1	0	0	0	4	0
Total	40	27	48	27	41	34	37	34	41	37	**207**	**159**

Figure 23

The Proportion of Statements between the App-related and the Other Sub-categories



App-related comments. A total of 180 App-related comments were made throughout the badminton season (89 in Class A; 91 in Class B). Nine subcategories for the general perceptions of the App and six subcategories for the performance-related comments were established. Students produced 73 positive comments regarding general perceptions that the App was ‘helpful/effective (39)’, ‘good/cool/like (21)’, ‘useful (8)’, and students are ‘excited (4)’ and ‘motivated (1)’. On the other hand, a few students ‘did not like the App (2)’ so they felt ‘bored (2). Some students ‘did not like (2)’ the App and they thought the App was ‘not helpful (2)’:

Table 9

Examples of the Positive and Negative Comments About the App

Positive perceptions about the App	Negative perceptions about the App
• The App was fun and helpful. • I like using a great video App because it made everything more visible and cooler. • I think it's important because it could help beginners. • Now we're in the championships (because of the App, partly my skills) • I got pretty good feedback from the App. • I was very excited to join the App and use all of the things it had. I learned many things such as skills and strategy.	• How I feel about the App is it's ok, but it should be used for a different sport. The App is useful, but I don't like it for badminton. • It made me worried because it is always too bad when I am recorded. • I was bored because in practice Colton would just wait for teacher to record him • It was a weird experience learning how to use an App. • I didn't like using the voice… • It was okay because there was no real good thing about it.

Students also made 100 performance-related comments (51 in Class A; 49 in Class B). For the skill-related topic, the comments showed students' positive process in skill development. They were able to see themselves (30 comments) from the App to fix their skills (14 comments). Moreover, the *Hudl Technique* App was used to employ tactical moves (21 comments) in students' game play, showing that their self-reported game performances were improved (28 comments):

Table 10

Examples of the Performance-related Comments

Skill-related	Tactic-related
• One thing that I learned today is that your posture affects the way that the birdie goes. If you turn sideway then it's easier for you to hit the birdie. • One thing that happened during this lesson is that I got to see where and how to improve my serve and how to serve a rally. • Our "advanced" team did very well in the game and that was important because the App helped us with teamwork and brand-new skill throughout the badminton class.	• What I learned with the App was to keep the opponent moving. A player and I have to go to the middle, every time I hit the birdie. • For example, one player had trouble with their backhand so I tried to hit the birdie in a way they would have to hit it back hand. I found that timing is also important. • I learned from the App how to observe my opponent and try to hit the birdie soft on hand when I need to. • I wasn't getting under the birdie, the App also helped me learn many strategies to use against my opponent.

Interviews with the Teacher about the Use of *Hudl Technique*

The thematic analysis process that was applied to the Physical Education teacher's daily reflection and two formal interviews generated three themes that describe the teacher's understanding and perceptions of the mobile App. The themes were: (a) *Survival to Impact*, (b) *Teacher's Student-centered Pedagogical Skill (Supporting Teaching)*, and (c) *Not Always 'APP'ropriate*. However, even though three different categories were defined, they are all related to each other.

Survival to impact. The teacher was interested in tools that would benefit his students and their skills in their Sport Education classes. He indicated wanting to have ways to integrate skills' assessments in a timely manner to complement the paper/pencil rules' tests he gave students for each sport. His very first daily reflection opened with the comment, "the kids seem to respond to it". Also, it was clear that his perception of the App would be tied to the students' use of it and benefit from its use:

> I was explaining to some of the kids how to use the App so I would show them how I did it and how I recorded the videos, and they seemed excited to use it during our next class (Day 2, daily reflection)…When you're using the App, you have to give them something specific to look for and to improve on because I can't just show them the video and not give feedback and instruction (Post-intervention interview).

As a teacher who has already noted his preference for technology that would help his students, it was clear that he liked how this App allowed students to learn more of the details of the skills, which resulted in their performance improving:

> …definitely the game play was pretty good today. Games were close and everybody played well…I don't know if there's any students that aren't fairly comfortable at this point with the game, which is nice to see (Day 16, daily reflection).

Pre/Post-intervention interviews indicated that the teacher's developmental level in technology moved up from 'Survival' to 'Impact':

> I think it definitely can. I think it depends on how well I use it… I feel like there's certain areas where I can, I'm pretty good. But then I definitely need help…I think as long as I can get it down, you know, definitely help (Pre-intervention interview).
>
> I definitely feel like I was doing more teaching (Post-intervention interview).
>
> …it definitely points me toward the possibility of using it because I before I would have never even considered it, but it's definitely something that, you know, I think it can be valuable and useful and worthwhile. It's just a matter of, am I going to put in the time and the effort to do it (Post-intervention interview).

He also noted that with more exposure, what he was recording and the feedback he gave through the App was better:

> …from the first day to the last day I definitely, you know, the quality of what I was able to produce was, you know, definitely a lot better (Post-intervention interview).

While the teacher was the only one who used the *Hudl Technique* App in Class A, Students in Class B used the App within their team members. It is evident that the teacher preferred the teaching environment in Class A:

> I felt like the first hour class (Class A) showed more improvement throughout the day (Day 4, daily reflection).
>
> It was probably easier for me to use it myself and teach the kids because they, you know, there's a lot to learn the skill, you know, the serve, …they're still learning the rules of the game and then adding the App in there. You know, just a lot at once I felt like, but I think that, by the end of it, they at least knew how to use it, you know, on a basic level. So hopefully, as the season goes on, they'll get better with it and kind of figure it out (Day 3, daily reflection).

Teacher's student-centered pedagogical skill. The teacher was optimistic about using technology in Physical Education. Previous to this intervention, he had integrated digital technology through the use of pre-recorded music or Google Classroom, which he described as helping him provide more individual instructions to students during and outside of class. Specific to the use of the *Hudl Technique*, the teacher's perceptions of the integration of the *Hudl* App into his badminton season were overall positive:

> … [this experience] points me toward the possibility of using it because before I would have never even considered it. But it's definitely something that, you know, I think can be valuable and useful and worthwhile (Post-intervention interview).

The teacher shared thoughts about how his normal style of teaching followed a pretty standard order of teacher demonstration of skills and student practicing the skills. In the case of the App, students were able to actually see themselves perform the movements:

> (I was able to)…focus on things that normally we kind of, you know, skip through (Post-intervention interview).

It was evident as well that the teacher's instruction with the App had been transferring from skill execution to tactical movement. In his first daily reflection, he noted that he was able to record each student and show them specific feedback about their form. When the students reflected on their play, the teacher was able to use technique-specific vocabulary (e.g., balanced positioning, footwork, backhand, and forehand) and critically analyze skill performance of students. By day 6, the teacher was using the video playback to give very detailed feedback about skills using phrases (e.g., wrist action, directing students to notice, or their position with arm). The *Hudl* App also allowed the teacher to ask critical thinking questions about tactics and to have the students demonstrate how their planning played out in rallies:

> Yeah, so I mean at the beginning it was very basic I was focusing on just, you know, like a serve… as we went through it was a little bit more of the rallies, back and forth. And just seeing if you know students made the right shot and things like that (Post-intervention interview).
>
> …it became more about strategy and we focused mainly on that. Because at that point, the students were able to get some pretty good rallies going, so they could see, you know, an entire progression of you know what they thought about their strategy and they were able to watch and see if they actually were able to implement this strategy (Post-intervention interview).

His above quotes are an indication that he felt very successful in his ability to teach students sport skills and tactics. Using the App, he provided students with different ways of learning, which he promoted by asking students to plan their strategy (i.e. he was referring to strategy as a game plan for students to win), enact the plan in the rally, and reflect on the outcome of their planning by talking through the play using the App. Rather than just talking about winning or losing through skills, the teacher found out that the App added the ability to review video and watch how a students' play caused the opponent to react (e.g., if their plan was to make the opponent "move back and forth", they had to watch the video and identify if the other student moved around the court).

Not Always 'APP'ropriate (Challenges). It takes time for the teacher to learn the App so he can teach it. It also takes students time to learn how to use it as well:

> It's just a matter of, am I going to put in the time and the effort to do it … it takes a lot of time to film and put together and you know just learning how to use it and then once I figured it out, and was able to make some decent videos, it was definitely time consuming and, you know, not easy to capture what I was looking for. Because it seems like a lot of times when I would film a rally, they wouldn't have a good rally I think sometimes they were nervous and then he was filming them so that was, you know, that was tough…(Post-intervention interview).

Resources were other challenges noted by the teacher. For example, even though the use of mobile App is useful, the teacher would need a tablet for each team to provide students with the same opportunities as Class B:

> I might probably have to get, you know, a tablet or something, if I was going to use [the App]. I don't know if my phone…would be, you know, big enough of a

> screen to be able to really see what we're doing … But I think if I had the technology, I would probably use it (Post-intervention interview).

The teacher expected that the students would naturally be excited about it, however, sometimes they would rather just be playing and practicing. It challenged the students to do more thinking and reflecting which they were not completely comfortable with:

> I think getting the kids to buy into it. I think that they didn't mind. When I did it and, you know, kind of, allowed them to just practice and play. But when our second hour (Class B) had to use it, that was tough to get them to use it the right way. They just kind of wanted to blow through it and not really take the time to make good videos. I did have some kids I did that. They definitely started to pick it up, but I just felt like they, you know, they would rather just be playing the game and practicing and, you know, competing (Post-intervention interview).

The teacher also thought about the proper time and place for effective use of the *Hudl* App, emphasizing that there should be a balance between the time for learning through the use of technology for better performance and the time for practicing after the App use.

> Yeah, I would say at the beginning of the season to anytime you show a new skill. I would say, you know, show a couple of skills and then use the app, and then maybe let them practice and get better at that skill for a while and then use it again when you're talking about strategy. I think that would be a good time to use it again.

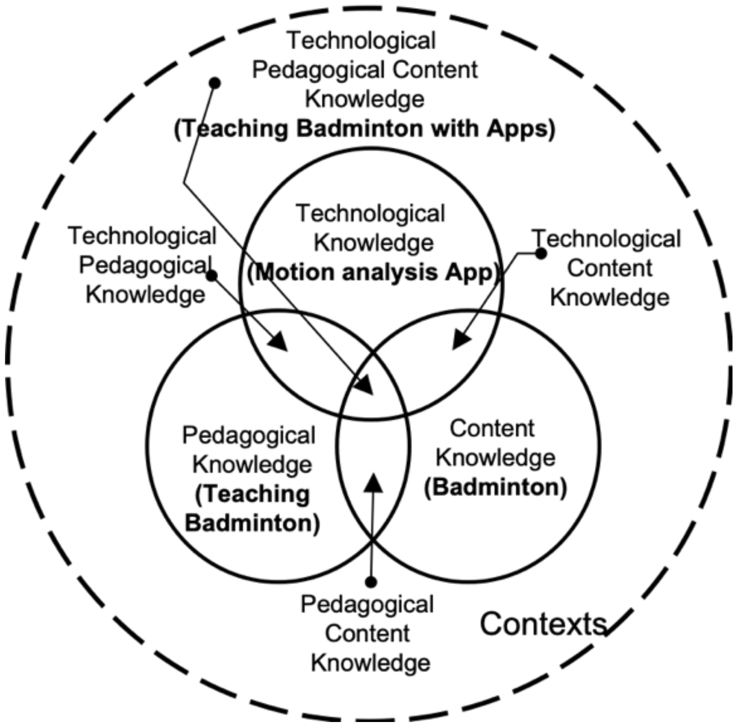
Discussion

As a qualitative portion of the larger project, this study was focused on the physical education teacher and students' perceptions on the use of the *Hudl Technique* App to better understand the effectiveness and the role of App technology on students' skill development and game play in a badminton season. Consistent with previous research (Casey & Jones, 2011; Hastie et al., 2010; Rossing et al., 2012), the use of technology had an influence on students' motor skill development, learning, and positive perceptions of the badminton Sports Education season in Physical Education. The details in the findings were helpful to not only identify the effectiveness of the App, but also to determine the clinical aspects of the App.

The theoretical framework called "model for learning with digital video" (Schwartz & Hartman, 2007) was applied in the study to support the four learning outcomes (i.e., engaging, seeing, doing, and saying). As students became interested in using the mobile App by recording videos (engaging), they developed their skills and game performance. After watching their own video (seeing), they put an intentional effort (doing) to do better in their performances during the team practices. Students were also asked to make review-videos by recording their voice with the video analysis using drawing tools (saying) to better understand their acquisition of fact and interpretation. By the end of the season, most students showed enjoyment and improved rallies by moving their opponents in the spot around the court with appropriate techniques and tactical moves.

Figure 24

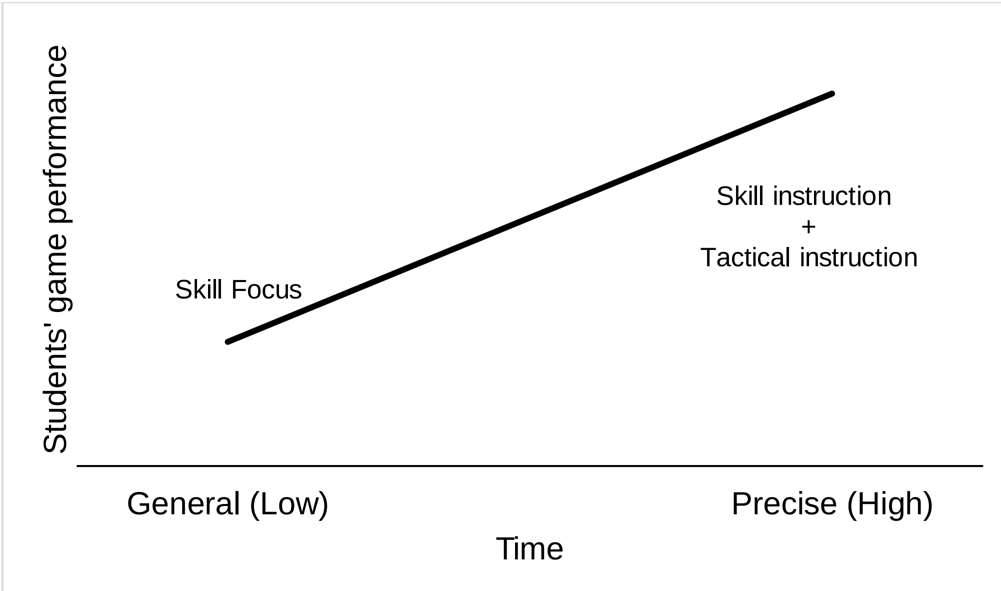
A Teacher's Application of TPACK



In addition, based on Koehler and Mishra (2009), the current study represented the teacher's pedagogical skill using technology in an innovative way to teach badminton content knowledge (See Figure 24). Within the context of the TPACK framework, it is important to see how the use of the App affected the teacher's teaching of badminton. The findings from the interviews with the teacher represent evidence that the three components of knowledge in Figure 23 (i.e., badminton content knowledge, teaching skill in badminton season, and the ability to use the *Hudl* App) should be complementary to enhance the TPACK.

Figure 25

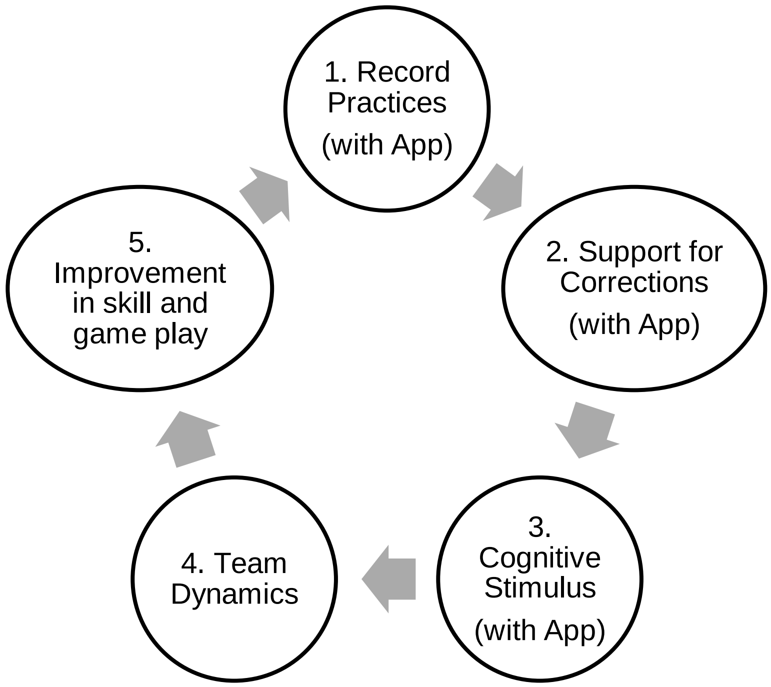
Teacher Instruction Complexity



The progression of what the teacher focused on through the use of the App started from learning to play badminton. As shown in the Figure 25, the teacher's instruction complexity (Koekoek et al., 2018) was initiated by focusing on each individual student learning proper form and execution of individual skills. Figure 26 describes the specific teaching and learning process while the teacher and students were using the App. The *Hudl* App was used during the first three phases and, as shown in the Figure, this recurring process occurred throughout the season. The teacher's TPACK and students' skill and game performance were improved while they were using the App. Based upon this finding, it is suggested that this teaching and learning process using the App could be applied to the other types of racquet sports such as tennis or racquetball.

Figure 26

Teaching and Learning Process While Using the App



Instant feedback from the live recordings is a unique feature of the *Hudl* App to develop skills and strategies. The specific focus on angles and performance of skills was only available from the playback in slow motion with a drawing tool in the App. Students' *App-related* comments in the critical incident sheets support the positive effects of self-feedback. In addition, following the team play feature of Sport Education, students were also challenged to provide peers with feedback on their game play performance through the App. The teacher focused the video playback on the movement of the opponent team by leading students to the critical thinking to see what happened on the other side of the net during rallies. Bringing a very cognitive and reflective aspect of team game play allowed the students to analyze their tactical moves during the games as well as to come up with new strategies to play against specific opponents. The teacher gave the students specific tasks to watch the video with a particular question depending on their performance and accordingly students were critically commenting on specific aspects of game play. Students' prompting right after their performance is also available only within the learning environment using live recordings. Even though the App technology offers potential in the sense of instructional strategies, research involved in mobile learning and the application of teaching strategies of mobile learning in Physical Education are limited. Given that most attention has been placed on higher education (Baran, 2014; Franklin & Smith, 2015), further research issues for mobile technologies in K-12 settings are recommended (Gubacs-Collins & Juniu, 2009; Rosenthal & Eliason, 2015).

It is worth considering having video analytics team as one of non-players roles in Sport Education. Even though a total of 180 *App-related* comments in the critical incident sheets provided the strong evidence that pedagogical aspects of the *Hudl Technique* influenced students' skill development and game play, inevitably, there were also some negative comments of the use of the App. Some of students were not motivated every time and wanted to have more time for practice and game play. In contrast, some students were motivated to play with the App being more likely to use it. Considering there are non-player roles in Sport Education, teachers could recruit video technicians who have more passion to use it to equip more expertise on video analysis for both skills and game play.

In addition, an appropriate amount of time and a proper timing for using the App need further study. The teacher pointed out the periodic use of the App instead of using it every class with every student, especially when students need to learn new skills and find their issues to focus on during game play. Time was one of the critical factors that determined the development of technique execution and game-based decision making (Miller, 2015). Even though longer lessons were used in the study, students had to spend substantial time recording video clips and learn how to effectively use the App with the recordings during the team practice time. However, there is no doubt that this would become less of an issue once students gain more experience.

Given that, motor skill competency has been emphasized for learning to play games and sports as the first national standard in Physical Education across time (NASPE, 1995; NASPE, 2004; SHAPE America, 2014), further research is warranted to determine whether students show good skill execution and game play as a result of their active use of App technology in different sports in K-12 Physical Education settings. Also, since little is known about the research on authentic assessment of technique and game performance (Harvey & Jarrett, 2014), keeping track of physical education teachers' and students' process of teaching and learning through the App technology will contribute to the authentic assessments as well as the development of instructional technology in Physical Education.

Conclusion

Within the design and the limitations of this study, the following conclusions are warranted: a) a physical education teacher can effectively integrate the use of a motion analysis App and strengthen instructional skills during regular instruction in a middle school badminton context. And b) the App provided students with active learning opportunities through instant feedback on skill and game performance. Further research is needed for implementing innovative and authentic teaching and learning environment with App technology.

CHAPTER 5

SUMMARY AND RECOMMENDATION FOR FUTURE RESEARCH

This study was focused on the value of the App technology through visual instruction and feedback for teaching badminton skills and game play, addressing central issues when badminton is taught using a motion analysis App, such as the students' skill and game performance levels, teacher and students' content knowledge, knowledge about the App, and the timing for the best use of the App. It is suggested from the findings from this study that, as an advanced video technology, the use of a motion analysis App can enhance teacher's instructional skills and students' learning experiences in Physical Education programs.

In the first study, it was demonstrated that, the use of the App helped the students to improve their skills and game performances during the Sport Education Badminton season. The students' scores were significantly increased across four time periods in both intervention classes. Since this study intentionally did not include the control group (not using the motion analysis App) in order for all students to receive benefits from the intervention (use of the motion analysis App), the current study findings cannot be directly compared to previous findings on skill tests, indicating no significant differences between experimental and control groups (Choi, 1996; Miller & Gabbard, 1988; Van Wieringer at el., 1989). However, as shown in Figure 11 in Chapter 3, students' skill test scores dramatically increased between the two skill tests in Day 1 and Day 10. As conveyed through the interview with the teacher, students were focusing on developing this badminton clear skill during this period. The critical incident data also reflected a prevalence of comments about skill improvement (31) that were detected in Day 8. The implication is that the immediate feedback through the motion analysis App in both classes positively affected students' skill improvement for all skill levels. Compared to the previous findings that high-skilled players showed better skill improvement than low-skilled players (Rikli & Smith, 1980; van Wieringen et al., 1989), the App may have the potential to help lower skilled students get better at executing badminton techniques.

With respect to the badminton game play performance, students' continuum of learning stages were demonstrated in the current study (see Figure 19): (a) team practice with video recording, (b) support for corrections from the teacher and peers with the App, (c) cognitive stimulus from feedback, (d) application of the feedback during team dynamics, and (e) improvement in skill and game play. The second stage (support for corrections) was the most important for developing student motor learning in this study because how students learn skills and strategies were different from traditional instruction. Even though students in both classes showed improvement in SE, students in Class B had greater improvement in SE than those in class A during the first half of the season while the teacher and students focused more on learning skills. Given that the students in Class B had more opportunities to use the App by themselves with less practice time, it is assumed that the improvement resulted from the opportunities for visual feedback through the App.

Another important finding is that while the students' mean SE scores had the similar pattern to their GPAI mean scores, students' tactical movement during the game play (DM and BA) increased more in Class A than the Class B during the second half of the season. This suggests that students' game performance was mostly determined by the DM and BA indices after student developed their skills at some point. Also, considering the higher scores in the two indices in ACTG class A, it is assumed that teacher's instruction through the App had an influence on students' tactical movements.

The second study was focused on the perceptions of both the teacher and the students in both class groups about the use of the *Hudl* App. With regard to the teacher's perceptions, it is evident that as the season progressed, the teacher gained confidence with teaching with the App and that his instruction was transferred from focusing his efforts on teaching skills to teaching strategies. This teacher's instruction complexity with technology throughout the badminton season (Figure 25) can also be suggested to use in teaching other racquet sports. According to Koehler and Mishra (2009), a teacher's technological pedagogical knowledge is an important part of teaching with technology. Therefore, it is suggested that in future research physical education teachers are equipped with their own video-based instruction guidelines. For instance, in this study, during the instructional time, students had opportunities to explain their decisions to solve their technical or tactical problems by using the voice recording through the App. Blomqvist, Luhtanen, Laakso, and Keskinen (2000) provided 20 arguments to determine the ability of secondary school students (11~14 years) to solve technical and tactical issues by finding answers among the arguments. Students can be asked to watch a series of their game performance video clips to choose the appropriate responses in certain situations. The teacher may instruct students on tactical movements based on the situations for making decisions (Blomqvist et al., 2000, p.330) when using *Hudl Technique* App. As students are watching their videotaped practices, they may describe their appropriate or inappropriate decisions from the video clips.

The results from the students' perceptions in the second study revealed that the self-didactical aspect of the use of the motion analysis App for students in learning badminton clear skills and game performance was useful. Suggestions for use of the motion analysis App from the second study are: (a) video analysis through the App has potential for self-feedback for learning different skills and tactical movements in different sports and (b) using qualitative approaches allow researchers to better understand the stakeholders' psychological views that are related to the treatment fidelity and learning process, while the teacher and students are using the App.

Based on insights gained from the second study, several constraints were shown when using the App in Physical Education contexts such as the time needed to learn specific features (e.g. drawing tools and split/overlay screen) and time needed to generate meaningful videos. The lack of badminton content knowledge and the App experience by the teacher and students may also be another challenge. Therefore, similar studies should be conducted to provide additional evidence regarding the effectiveness of the instructional aspects of the App.

Recommendations for Future Areas of Research

In sum, further research on the use of such mobile technologies should be focused on: (a) how the App technology can be innovative to foster student learning in game play in Physical Education settings, and (b) how teachers understand the use of technology along with their pedagogical skills. To be specific, there are several recommendations for future research regarding App technologies.

First, replications of this study are needed with different settings (i.e., populations, grade levels, schools, and curriculum) to identify whether the participation and settings are appropriate to start integrating the use of technologies like the *Hudl* App. Second, it is important to gauge how and when the App technology can enhance teachers' instruction and affect student actual learning. In this regard, research design modification (e.g., having a control group or differentiate the time to introduce to having students use the App) may give researchers valuable information on using *Hudl* App. Third, the use of the App in different content contexts is needed. Different contexts would include the types of sports/activities (e.g., target game, invasion/territory game, net/court game, and field/striking game) and types of skill (e.g., closed skill in golf swing and open skill in soccer kicking) as well as focus on tactical dimensions of performances in different sport settings (e.g. difference of tactical movements in defense between football and soccer).

As stated in the National Physical Education standards (SHAPE, 2014), the essence of Physical Education is to develop competent/skillful persons. Supporting the effectiveness of the use of the App for both the teacher and students, further studies are needed using the concrete structure of learning environment to support the advancement of self-directed teaching and learning with educational technologies.

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APPENDIX I

IRB PROTOCOL

Instructions and Notes:

- Depending on the nature of what you are doing, some sections may not be applicable to your research. If so, mark as "NA".
- When you write a protocol, keep an electronic copy. You will need a copy if it is necessary to make changes.

1 Protocol Title

Include the full protocol title: The Effects of Digital Technology (Apps) on Skill Performance in Physical Education

2 Background and Objectives

Provide the scientific or scholarly background for, rationale for, and significance of the research based on the existing literature and how will it add to existing knowledge.

- Describe the purpose of the study.
- Describe any relevant preliminary data or case studies.
- Describe any past studies that are in conjunction to this study.

Background:

Technology in physical education has the potential to provide teachers with a variety of teaching avenues, help students learn the skills and knowledge towards physical activity that they need throughout their lifetime (Palao, Hastie, Cruz, & Ortega, 2015). The advance of digital technology has opened different ways for individuals to communicate, collaborate, and produce new constructs (Groff, Klopfer, Osterweil, & Haas, 2009). Today's adolescents are fully accepting these types of technology to integrate them into various aspects of their daily lives (Green & Hannon, 2007; Rosenthal & Eliason, 2015). Accordingly, the scope of education in using technology has been changing in physical education and schools and teachers are trying to keep track of the increasing demands of technology innovations (Krause, Franks, & Lynch, 2017). Krause et al. (2017) reported technology as one of the most frequently mentioned topics where teachers are requesting more information on it from the online forum, the Society of Health and Physical Educators (SHAPE America) Exchange. The types of technology may include pedometers/accelerometers, heart rate monitors, Exergames/Active video games (AVG), and portable digital technologies such as smartphones and tablets that include mobile applications (Apps) (Krause & Sanchez, 2014). However, even though numerous educational technology resources have been available in physical education, many professionals are still asking questions regarding how to use and implement technology resources to reach students' needs and improve their ultimate learning outcomes as well as how to tie technological outcomes to the national standards (Krause et al., 2017).

The purpose of this study is to determine the effects of using a motion analysis mobile application on students' skill development and game play in physical education. For a specific skill development in a sport, badminton skills will be examined. Accordingly the main research questions are as follows: (a) does use of the movement analysis App (*Hudl Technique*) improve students' badminton technique performance in a badminton season?; (b) does the video-based feedback using *Hudl Technique* improve students' game play?

The second purpose of this study is to explore both a teacher and students' perceptions of a video technology (a motion analysis mobile application) used in physical education classes via interviews and document analysis. The stakeholders' experiences in the study will be helpful to better understand the effectiveness and the role of video technologies using mobile devices on students' skill development in physical education. Research questions are as follows:

3. What are the teacher's views of using a motion analysis mobile App (advanced video technology)?
4. What are the students' learning experiences using a motion analysis mobile App (advanced video technology)?

3 Data Use

Describe how the data will be used. Examples include:

- Dissertation, Thesis, Undergraduate honors project
- Publication/journal article, conferences/presentations
- Results released to agency or organization
- Results released to participants/parents
- Results released to employer or school
- Other (describe)

The data produced by this project will be used for graduate student dissertation, publications and presentations. Overall statistical results as well as any publications will be shared with the teacher participant.

4 Inclusion and Exclusion Criteria

Describe the criteria that define who will be included or excluded in your final study sample. If you are conducting data analysis only describe what is included in the dataset you propose to use.
Indicate specifically whether you will target or exclude each of the following special populations:

- Minors (individuals who are under the age of 18)
- Adults who are unable to consent
- Pregnant women
- Prisoners
- Native Americans
- Undocumented individuals

Middle school students and a physical education teacher will be involved in this research. The methodology involved requires participants to use a mobile application to measure students' skill improvement.

5 Number of Participants

Indicate the total number of participants to be recruited and enrolled*:*
25-35 students in three classes will be involved in the study. Therefore, there will be a maximum of 150 participants.

6 Recruitment Methods

- Describe who will be doing the recruitment of participants.
- Describe when, where, and how potential participants will be identified and recruited.
- Describe and attach materials that will be used to recruit participants (attach documents or recruitment script with the application).

A physical education teacher will be contacted for participating in this research. Students (three classes) will be recruited by the teacher.

7 Procedures Involved

Describe all research procedures being performed, who will facilitate the procedures, and when they will be performed. Describe procedures including:

- The duration of time participants will spend in each research activity.
- The period or span of time for the collection of data, and any long term follow up.
  The experts will be asked to return their questionnaires within 2 weeks of receipt.
- Surveys or questionnaires that will be administered (Attach all surveys, interview questions, scripts, data collection forms, and instructions for participants to the online application).
- Interventions and sessions (Attach supplemental materials to the online application).
- Lab procedures and tests and related instructions to participants.
- Video or audio recordings of participants.
- Previously collected data sets that that will be analyzed and identify the data source (Attach data use agreement(s) to the online application).

The intervention will be performed for 4 weeks. During the intervention, students' game play will be recorded by using video camera to analyze students' skill development and their game performance and involvement. After the intervention, students will be asked to fill out a paper survey consisting of 20 questions. This is expected to take between 5-10 minutes to complete. The interview with the teacher will be performed before and after intervention.

8 Compensation or Credit

- **Describe the amount and timing of any compensation or credit to participants.**
- **Identify the source of the funds to compensate participants**
- **Justify that the amount given to participants is reasonable.**
- **If participants are receiving course credit for participating in research, alternative assignments need to be put in place to avoid coercion.**

There is no financial compensation associated with participation in this study.

9 Risk to Participants

List the reasonably foreseeable risks, discomforts, or inconveniences related to participation in the research. Consider physical, psychological, social, legal, and economic risks.

There are no known risks associated with participation in this study at this time; beyond the normal risk of participating in a physical education class.

10 Potential Benefits to Participants

Realistically describe the potential benefits that individual participants may experience from taking part in the research. Indicate if there is no direct benefit. Do **not** include benefits to society or others.

The teacher may benefit through the intervention becoming more aware of the use of digital technology and hybrid curriculum model. Students will be able to develop their sport specific technique and game performance through the intervention.

11 Privacy and Confidentiality

Describe the steps that will be taken to protect subjects' privacy interests. "Privacy interest" refers to a person's desire to place limits on with whom they interact or to whom they provide personal information. Click here for additional guidance on ASU Data Storage Guidelines.

Describe the following measures to ensure the confidentiality of data:

- Who will have access to the data?
- Where and how data will be stored (e.g. ASU secure server, ASU cloud storage, filing cabinets, etc.)?
- How long the data will be stored?
- Describe the steps that will be taken to secure the data during storage, use, and transmission. (e.g., training, authorization of access, password protection, encryption, physical controls, certificates of confidentiality, and separation of identifiers and data, etc.).
- If applicable, how will audio or video recordings will be managed and secured. Add the duration of time these recordings will be kept.
- If applicable, how will the consent, assent, and/or parental permission forms be secured. These forms should separate from the rest of the study data. Add the duration of time these forms will be kept.
- If applicable, describe how data will be linked or tracked (e.g. masterlist, contact list, reproducible participant ID, randomized ID, etc.).

If your study has previously collected data sets, describe who will be responsible for data security and monitoring.

Six video cameras will be placed next to six badminton courts. Videos and pictures (screenshots from the videos) will be taken to collect students' skill execution and game performance during the whole badminton lessons. Students will be assigned a research number Only research team will have access to the data. All data will be coded and confidential with only the research team having access to the key (tying participants to surveys). The raw data will be stored in a locked file office of physical education department 330 G Santa Catalina building.

12 Consent Process

Describe the process and procedures process you will use to obtain consent. Include a description of:

- Who will be responsible for consenting participants?
- Where will the consent process take place?
- How will consent be obtained?
- If participants who do not speak English will be enrolled, describe the process to ensure that the oral and/or written information provided to those participants will be in that language. Indicate the language that will be used by those obtaining consent. Translated consent forms should be submitted after the English is approved.

Informed consent will be provided through the paper survey prior to beginning the survey questions.

13 Training

Provide the date(s) the members of the research team have completed the CITI training for human participants. This training must be taken within the last 4 years. Additional information can be found at: Training.

Pamela Kulinna, 7/31/17 ; Hyeonho Yu, 6/16/19

APPENDIX II

PARENTAL LEETER OF PERMISSION

ARIZONA STATE UNIVERSITY: PARENTAL LETTER OF PERMISSION

September 2019
Dear Parent:

I am Hyeonho Yu, a PhD student working with Dr. Pamela Kulinna in the Mary Lou Fulton Teachers College at Arizona State University. I am conducting a research study investigating the effectiveness of using motion analysis mobile application.

I am inviting your child's participation as a research participant in our project. During a normal school day, your child will be involved in the physical education curriculum. These regular school activities may include, participating in a badminton season in the classroom while using a motion analysis mobile application on students' skill development; filling out surveys about how she/he feels about the use of the App in physical education classes; open-ended interview (if necessary) about their perceptions of using the App on their badminton skill development.

Your child will be participating in these school activities as part of their normal school day; however, I am asking your permission to use your child's surveys and badminton skill tests as data in this research, so we can share this information to help other schools and teachers. During the game play, your child will be videotaped to measure their game performance, but the video will not be shared with anyone but the research team coding behaviors without names. Thus, we are requesting permission for your child to participate as a research participant.

Your child's participation in this study is voluntary. If you choose not to have your child participate or to withdraw your child from the study at any time, there will be no penalty and it will not affect your child's grade. The results of the research study may be published, but your child's name will not be used.

There may be no direct benefit to your child for allowing us access to his/her data; however, the benefits include learning more about badminton specific skills and game performance and how to use technology in learning. There are no foreseeable risks or discomforts to your child's participation.

The responses and scores of your child will be confidential. The results of this study maybe used in reports, presentations, or publications but your child's name will not be known.

If you have any questions concerning the research study or your child's participation in this study, please call me at (480) 727-1767.

Sincerely,
Pamela Kulinna, Ph.D

By signing below, you are giving consent for your child (Child's name) to participate in the above study.

Signature Printed Name Date

If you have any questions about you or your child's rights as a subject/participant in this research, or if you feel you or your child have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the Office of Research Integrity and Assurance, at (480) 965-6788.

We would like to take pictures and videos of students engaged in the Physical Education curriculum **to use in newspaper or research articles or presentations**. By signing below, you are giving us permission to use pictures of your child in normal classroom Physical Activities.

Signature Printed Name Date

APPENDIX III

ADAPTING FEATURE OF SEM IN BADMINTON SEASON

Three main features from the SEM (i.e., relatively longer season, team affiliation, and formal competitions) were used to ensure effective skill learning. There was evidence that the longer period of play within the entire sport season allowed students to develop skill competence, provided them with equal opportunities to participate in the class, and contributed to their team success (Hastie, 1998). The formal competition with the persisting team within longer season format is also helpful for researchers to collect adequate and credible skill and game performance data. The purpose of the adaptation of the features are to help students to reduce the time spent in acquisition so that they can gradually approach to the actual game conditions. Depending on participants' abilities in skills and tactical movement, the proportion of skill mastery during a team practice can be possibly changed throughout the season implementation. The Table shows the badminton season schedule within SEM, along with the schedule of skill tests.

Badminton Season Outline for Intervention Classes Using Mobile App

Lesson	Focus	Teacher's role	Students' role
1	**Skill tests (clear shot)** Introduction to badminton (Rules & beginning skills)	Program director	Performer Skill test helper

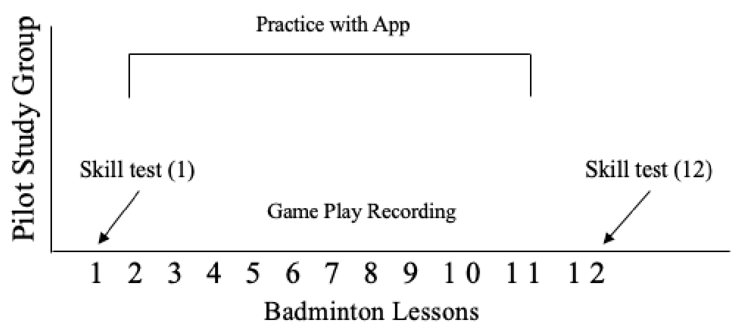
2-9	Team allocation Practice competition (Focus more on ***Acquisition and Structuring Tasks***) Skill instruction **using mobile App** (Whole class) Video recording for game play assessment	Head coach Umpire advisor App user (Class A)	Player Scorekeeper App user (Class B)
10	**Skill tests (clear shot)**	Program director	Performer Skill test helper
11-19	Formal competition (Focus more on ***Structuring and Adaptation Tasks***) Video recording for game play assessment	Program director App user (Class A)	Player Scorekeeper App user (Class B)
20	**Skill tests (clear shot)**	Program director	Performer Skill test helper
Retention Test	**Skill tests (clear shot)**	Program director	Performer Skill test helper

APPENDIX IV

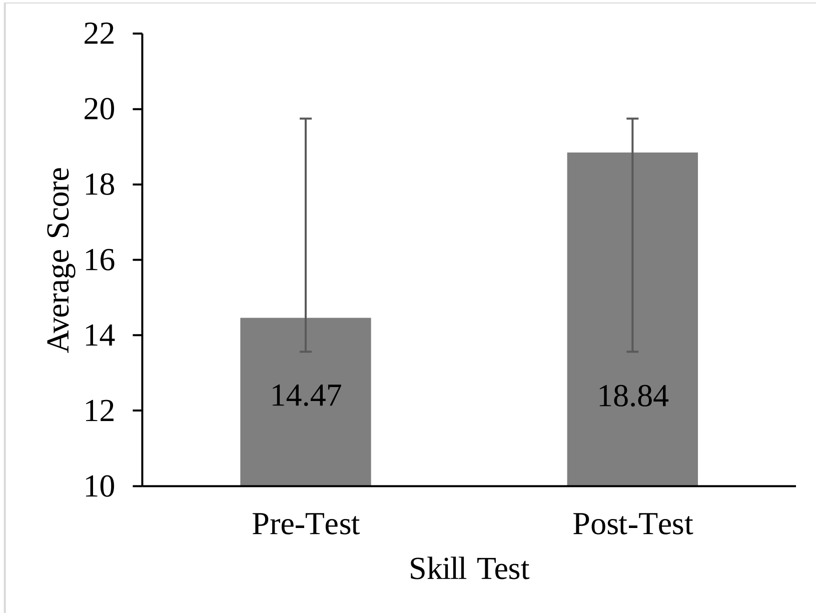
PILOT STUDY

Participants and Settings

In order to verify if the intervention program could be applied to real learning environment, a pilot study was performed before the intervention started. Participants (16 male and 5 female students) were collegiate students who enrolled a badminton basic course at a university in the southwestern area in US. They were not in either a Physical Education or health related major. The pilot study was held in a fitness center at the university in a gymnasium with six badminton courts. The students were asked to perform two clear shot skill tests at the beginning and the end of semester. Students' game plays were videotaped to find good angles for videotaping and for research training. The figure below shows the planning of the pilot study.



The bar graph shows the clear shot result from the pilot study. A paired sample *t*-test was performed on a sample of 21 collegiate students to determine whether there was a statistically significant mean difference between pre- and post-clear shot test. Participants had significantly higher scores in post-test (18.84 ± 3.89), compared to the pre-test (14.47 ± 7.60), $t(18) = 2.820$, p=.011.


22
20
18
16
14
12
10
Average Score
14.47
18.84
Pre-Test
Post-Test
Skill Test

APPENDIX V

OPPORTUNITY TO RESPOND (OTR) INSTRUMENT

Calculation of the Percentage of Skill Execution Using OTR Observation Instrument

<table>
<tr><th colspan="2" rowspan="2">Opportunity to Respond (OTR) Test</th><th colspan="4">Product</th></tr>
<tr><th colspan="2">Successful</th><th colspan="2">Unsuccessful</th></tr>
<tr><td rowspan="4">Process</td><td rowspan="2">Acceptable</td><td>///// ////</td><td></td><td>///// /</td><td></td></tr>
<tr><td></td><td>9</td><td></td><td>6</td></tr>
<tr><td rowspan="2">Unacceptable</td><td>////</td><td></td><td>/</td><td></td></tr>
<tr><td></td><td>4</td><td></td><td>1</td></tr>
<tr><th colspan="6">Percentage Calculation of Skill Execution</th></tr>
<tr><td colspan="3">(Acceptable & Successful)/Total number of shots *100= 9/20 *100 = 45%</td><td colspan="3" rowspan="2">(Acceptable/Total number of shots *100= 15/20*100 = 75%</td></tr>
<tr><td colspan="3">(Acceptable & Unsuccessful)/Total number of shots*100= 6/20100 = 30%</td></tr>
<tr><td colspan="3">(Unacceptable & Successful)/Total number of shots *100= 4/20*100 = 20%</td><td colspan="3" rowspan="2">(Unacceptable/Total number of shots *100= 5/20*100 = 25%</td></tr>
<tr><td colspan="3">(Unacceptable & Unsuccessful)/Total number of shots 100= 1/20*100=5%</td></tr>
</table>

Maximum opportunity to engage student in games

Within rallies, students rotated if they won twice or lost to promote their maximum game participation as well as to prevent a small number of students' domination during team play.

APPENDIX VI

MEAN AND SD FOR SKILL AND GAME PERPORMANCE

Mean and standard deviation scores throughout the season

Day	Class	Mean	Standard Deviation
1	ACTC Class A	27.10	19.279
	ACTC Class B	32.31	20.848
	Total	29.42	19.873
10	ACTC Class A	43.85	14.449
	ACTC Class B	47.00	11.396
	Total	45.25	13.096
20	ACTC Class A	49.45	11.610
	ACTC Class B	49.88	10.880
	Total	49.46	11.133
Two Weeks Later	ACTC Class A	55.65	10.825
	ACTC Class B	57.13	10.570
	Total	56.31	10.585

Means and standard deviation for the GPAI data throughout the season

	Class	Mean	*s*
GPAI-1	Class A	0.4208	.137
	Class B	0.4217	.133
GPAI-2	Class A	0.5350	.131
	Class B	0.5418	.121
GPAI-3	Class A	0.6512	.105
	Class B	0.6128	.084
SE_A-1	Class A	0.2557	.139
	Class B	0.2641	.126
SE_A-2	Class A	0.2740	.107
	Class B	0.2756	.097
SE_A-3	Class A	0.3359	.136
	Class B	0.3530	.101
SE_S-1	Class A	0.5555	.203
	Class B	0.5371	.186

SE_S-2	Class A	0.6779	.167
	Class B	0.6815	.124
SE_S-3	Class A	0.7794	.108
	Class B	0.7440	.079
DM-1	Class A	0.1726	.105
	Class B	0.2047	.089
DM-2	Class A	0.2412	.148
	Class B	0.2691	.140
DM-3	Class A	0.3969	.119
	Class B	0.3479	.117
BA-1	Class A	0.5343	.174
	Class B	0.5233	.163
BA-2	Class A	0.6860	.156
	Class B	0.6750	.125
BA-3	Class A	0.7775	.110
	Class B	0.7465	.077

Note. Three periods in each component indicates the day for the first game play, day 9, and the last game play (e.g., GPAI 1: GPAI data for the first game play; GPAI-2: GPAI data for the Day 9; GPAI-3: GPAI data for the last game play).

APPENDIX VII

OTR TRENDS IN CLASS A & B

High-skilled Students' ORT Trends in Class A

Day	S+A	US+A	S+UA	US+UA
4	37.20%	3.56%	51.51%	7.73%
5	38.18%	3.33%	54.50%	3.98%
6	34.04%		52.87%	13.08%
7	34.97%		51.58%	13.45%
8	22.56%	1.79%	61.94%	13.72%
9	24.66%		62.48%	12.85%
11	42.65%		39.32%	18.03%
12	31.05%		53.25%	15.70%
13	28.56%	0.78%	56.27%	14.39%
14	33.67%		55.10%	11.22%
15	34.94%		51.83%	13.23%
16	44.35%		33.47%	22.18%
17	49.26%		39.62%	11.12%
18	46.38%	0.72%	47.83%	5.07%
19	49.13%		34.75%	16.12%

Note. S=successful, US=unsuccessful, A=Acceptable, US=unacceptable

High-skilled Students' ORT Trends in Class B

Day	S+A	US+A	S+UA	US+UA
4	20.54%	25.00%	37.50%	16.96%
5	28.37%	1.25%	57.16%	13.22%
6	35.09%	0.71%	39.95%	24.25%
7	25.57%	0.47%	54.53%	19.43%
8	38.46%		30.77%	30.77%
9	33.65%		48.08%	18.27%
11	30.63%		50.07%	19.31%
12	29.15%		51.06%	19.79%
13	35.26%	0.36%	44.37%	20.01%
14	34.82%		47.18%	18.00%
15	50.68%		35.61%	13.72%
16	47.60%		30.02%	22.37%
17	56.47%		32.28%	11.25%
18	50.00%		35.71%	14.29%
19	43.31%		37.89%	18.80%

Note. S=successful, US=unsuccessful, A=Acceptable, US=unacceptable

Low-skilled Students' ORT Trends in Class A

Day	S+A	US+A	S+UA	US+UA
4	34.87%		18.91%	46.22%
5	40.81%		24.52%	34.68%
6	20.32%		43.39%	36.29%
7	22.88%		44.10%	33.01%
8	28.21%	0.69%	47.20%	23.89%
9	27.61%		50.34%	22.05%
11	25.58%		50.38%	24.04%
12	28.74%		53.30%	17.96%
13	35.16%		38.90%	25.93%
14	30.68%		50.05%	19.28%
15	20.51%		63.59%	15.90%
16	25.41%	1.04%	52.97%	20.59%
17	26.57%		53.27%	20.17%
18	17.39%		65.22%	17.39%
19	32.70%		56.10%	11.20%

Note. *S=successful, US=unsuccessful, A=Acceptable, US=unacceptable*

Low-skilled Students' ORT Trends in Class B

Day	S+A	US+A	S+UA	US+UA
4	16.67%	5.56%	27.78%	50.00%
5	6.52%	4.55%	33.40%	55.53%
6	22.22%		31.48%	46.30%
7	24.01%		44.44%	31.55%
8	19.06%	2.53%	38.52%	39.89%
9	26.72%		42.25%	31.03%
11	17.71%		44.41%	37.88%
12	32.47%		40.69%	26.84%
13	24.22%	0.68%	44.10%	31.00%
14	27.15%		44.92%	27.92%
15	32.17%		41.39%	26.44%
16	31.66%		34.75%	33.59%
17	34.15%		37.30%	28.55%
18	35.09%	1.36%	33.52%	30.03%

Note. S=successful, US=unsuccessful, A=Acceptable, US=unacceptable

APPENDIX VIII

TEACHER INTERVIEW QUESTIONS

Pre-intervention semi-structured interview questions

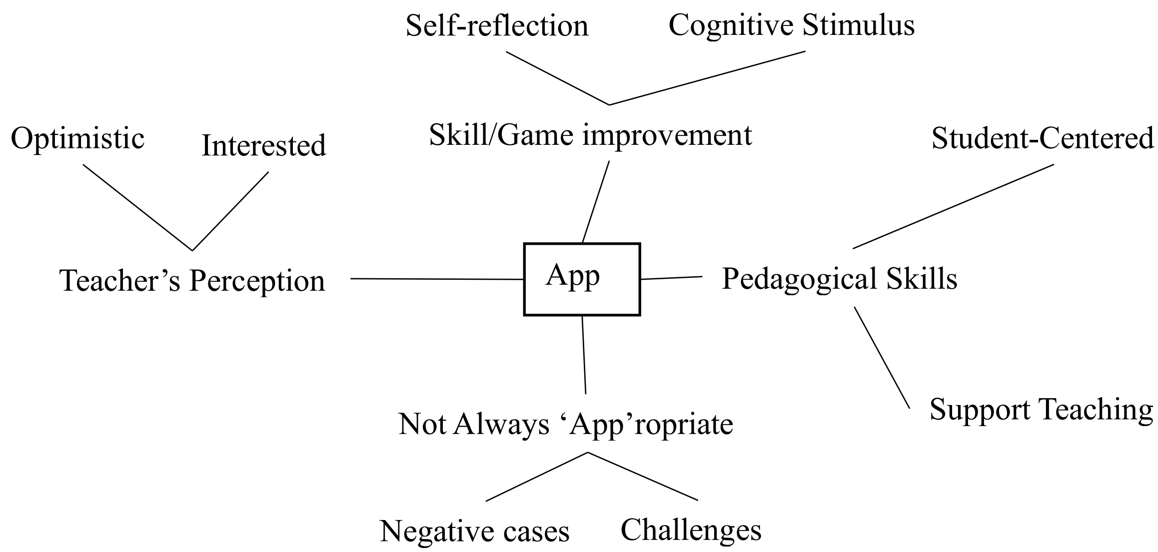
1. Do you understand the curriculum that will be used in this study (the hybrid curriculum using Sport Education model and Game-Based Approach)?
2. Do you know your students' motor skill levels? If yes, how did you know that?
3. What kinds of technology are you using in your teaching in physical education classes? If not, why? If yes, why?
4. Have you heard about the motion analysis (*Hudl Technique)* mobile App?
5. Could you please talk about your developmental level in using technology in his physical education program?

Post-intervention semi-structured interview questions

1. Please tell me your experiences that were the most influential to you when using the *Hudl Technique.*
2. To what extent, and in what ways do you think did the use of the Hudl App impact students' skill and game play development? How could you tell?
3. Compared to your teaching without the *Hudl Technique*, please describe when the instruction with the App happened what you felt when using the *Hudl Technique*
4. What do you see as the main advantages and disadvantages of the App? Do you plan to continue to use the *Hudl Technique*? Why, or why not?
5. What was the more difficult aspect of using *Hudl*? Why?,
6. What suggestions would you have for other teachers who are considering using it?

APPENDIX IX

THEMATIC MAP FOR THE TEACHER’S PERCEPTION OF APP


Self-reflection
Cognitive Stimulus
Optimistic
Interested
Skill/Game improvement
Student-Centered
Teacher's Perception
App
Pedagogical Skills
Support Teaching
Not Always 'App'ropriate
Negative cases
Challenges