Je-LKS
PEER REVIEWED PAPERS
Vol. 13, n.2, 2017
ISSN: 1826-6223 | eISSN: 1971-8829
Journal of e-Learning and Knowledge Society
The Italian e-Learning Association Journal

EMPLOYING TABLET TECHNOLOGY FOR VIDEO FEEDBACK IN PHYSICAL EDUCATION SWIMMING CLASS

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Keywords: Physical education, Technology integration, Video feedback, Swimming, Tablets.

Although technology has found its way into modern physical education (PE), technology-"unfriendly" environments beyond the gym, such as swimming pools, still haven't been focused on in terms of technology-enhanced teaching and research efforts. Approaching this blind spot, the main objective of this study was to determine the impact of technology-enhanced video feedback on swimming performance, particularly using a tablet computer. Two 5th grade PE swimming classes were randomly assigned experimental group (n = 16) and control group (n = 15). Experimental group students were exposed to a standardized video analysis and feedback program using a tablet computer by a trained PE teacher for 7 weeks. The control group PE swimming class didn't integrate any media and technology at all and used traditional teaching methods such as verbal feedback only. Students' swimming performance for front crawl was measured at baseline and after the 7-weeks class period using a pre-post test design. Experimental group

for citations:
Kretschmann R. (2017), *Employing Tablet Technology for Video Feedback in Physical Education Swimming Class,* Journal of e-Learning and Knowledge Society, v.13, n.2, 103-1115.
ISSN: 1826-6223, e-ISSN:1971-8829
DOI: 10.20368/1971-8829/1322

students significantly ($p < 0.05$) improved in front crawl racing-results from pre- to post-test. Semi-structured interviews with selected experimental group students revealed that the students judged the video feedback scenario using a tablet computer being helpful for their learning process of improving their front crawl technique and eventually their race results. Conclusively, video feedback via tablet technology in PE swimming classes served as a sufficient and effective teaching method for improving front crawl swimming performance in 5th grade students. The teaching scenario proved to be superior compared to traditional teaching methods and feasible in the swimming pool environment.

1 Introduction

Modern physical education (PE) has opened itself for technology integration (e.g., Kretschmann, 2015; Mohnsen, 2012). Various technologies have found its way into regular PE classes, especially mobile devices such as (digital) cameras (Lim, Henschel Pellett & Pellett, 2009), smart phones (Cummiskey, 2011), laptops (Kretschmann, 2010), and tablet computers (Nye, 2010).

However, there are technology-"unfriendly" teaching environments beyond the gym that still haven't been focused on prominently in terms of technology-enhanced teaching and research efforts. These spaces contain swimming pools, track and field stadiums, and other outdoor areas and settings (e.g., tennis courts, soccer fields, rock climbing areas, mountain bike race tracks, parks, etc.) (Kretschmann, 2010).

Integrating technology into those technology-unfriendly PE settings may be regarded as an important task and chance to fully accomplish covering PE in its diverse facets. Particularly, motor skills acquisition and motor development can be fostered through technology, featuring the psychomotor learning domain (Mitchell, McKethan & Mohnsen, 2004).

Swimming is mandatory in the German PE, covered by national and state level PE curriculums (Prohl & Krick, 2006). In this case, improving PE students' swimming performance and technique appears to be the obvious mandatory task. Simply speaking, without the ability to swim, students are not able to conquer the element water at all. Swimming class PE students' learning outcomes therefore primarily focus on swimming performance in deep water swimming pools.

As feedback is an utmost valuable asset in improving students' motivation and motor performance (Harris, 2009; Koka & Hein, 2003), technology-enhanced video feedback may provide an ideal application of teaching efforts. Providing PE students with instant feedback on their swimming technique on-hand right after their individual swimming performances may boost their learning outcomes exponentially, compared to traditional forms of feedback (Boyce *et al.*, 1996; Lees, 2002).

The idea is that students can see themselves, taking a mental step back from the first-person intrinsic perspective to a third-person point of view, comparing the subjective with the objective human movement outcome via video on screen (Hamlin, 2005). Additional teacher feedback guides students' attention to the essential movement parts, potentially making the learning experience even more in-depth and valuable.

2 Literature Review

Literature research on digital video feedback in PE revealed diverse terminology. Terms as "augmented feedback", "enhanced-video", "annotated video", "technology-based feedback", and "video-mediated instruction" popped up. "Multimedia" and "computer-assisted instruction (CAI)" were also featured prominently among practice and research papers.

From the conceptual point of view, video feedback has the potential to engage students in self-assessment and peer assessment, including teacher-mediated feedback conditions. According to Hamlin (2005, p. 8), using video technology for feedback purposes can help students to "'step outside themselves' to become actively involved in a process of making adjustments. Skill adjustments occur immediately during skill practice and again after viewing the videotape. Students use the video to better visualize and reflect on errors, strengths, and weaknesses".

Hamlin (2005, p. 8) also emphasizes on the slow motion ability that adds a "unique dimension to learning", as essential elements of a movement can be picked out and focused on using particular cue points. Furthermore, recorded student performance data can be stored and accessed later, preserving data loss compared to direct observation (Darden & Shimon, 2000).

Surprisingly, as video feedback may be regarded as one of the premier scenarios of technology use in PE (Kretschmann, 2010) and despite a decent number of practice papers (e.g., Darden & Shimon, 2000; Harris, 2009), little empirical evidence on video feedback in PE could be identified. These studies will be presented in alphabetic order in the following paragraphs.

Brooker and Daley-James (2013) examined British year-two class students. They used information and communication technology (ICT) for video feedback to improve children's technique in gymnastics. The findings showed that ICT improved the plan, perform, and evaluate stages, and the children's technique.

Boyce *et al.* (1996) compared the effectiveness of peer, teacher, and video feedback with teacher cuing during elementary students' skill development units in PE (overhead pass, and forearm strike in tennis). They found that teacher-directed feedback was more effective in younger students, whereas video feedback with teacher cuing was more effective for older students.

Casey and Jones (2011) investigated using digital video feedback technology for enhancing student engagement in year seven PE students. Students showed a deeper understanding of throwing and catching and an enhanced engagement level in PE.

Harvey and Gittins (2014) applied a game-centered approach (GCA) to British middle school PE students, integrating video-based feedback into a teaching games for understanding (TGfU) soccer unit. Using an experimental design with two different video-feedback scenarios and one control group, results showed statistically significant improvements in both video-feedback groups according to game performance.

O'Loughlin, Ní Chróinín and O'Grady (2013) employed digital video feedback in elementary PE students aged 9-10 years for improving basketball skills. Digital video was used to provide feedback and to support self-assessment via rubrics. Student performance was positively impacted by self-assessment using digital video. Student motivation and engagement also increased through using digital video.

Palao, Hastie, Cruz and Ortega (2013) tested secondary school PE students in regard to skill improvement and knowledge gain for the track and field discipline hurdles, applying three different feedback conditions: a) verbal feedback by the teacher, b) video and teacher feedback, and c) video and student feedback. The video and teacher feedback condition showed statistically significant improvements in skill execution, technique, and knowledge, and therefore proved to be the most effective one.

Tanaka, Murakami, Kakoi, Wada and Takahashi (2014) used tablets for instant video feedback in Japanese PE students. Evaluation questionnaires showed that the vast majority of the students found video necessary and useful during the learning process.

Conclusively, empirical evidence on digital video feedback in PE is limited, especially regarding tablet technology, since - to our knowledge - there is only one study report available on this technology asset (Tanaka *et al.*, 2014). Nevertheless, all featured studies reported positive results. However, to cover the full picture, negative results of implemented digital video feedback for motor skill learning have also been reported (Emmen *et al.*, 1995), although that study did not feature PE and did not employ up-to-date modern technology compared to today's standards.

3 Methodology

3.1 Objectives

The main objective of this study was to determine the impact of a technology-enhanced teaching scenario in PE featuring video feedback on swimming performance, particularly using a tablet computer. Secondly, feasibility of integrating tablet technology via the technology-enhanced teaching scenario in the swimming pool-based PE environment should be judged on.

3.2 Hypotheses

Following the main objective, two main hypotheses of this study can be stated:

- H1: It was predicted that a tablet-computer-enhanced video-feedback teaching-scenario (experimental group) in PE significantly improves student's swimming performance (25 meter front-crawl race-performance).
- H2: It was predicted that a tablet-computer enhanced video-feedback teaching-scenario (experimental group) in PE improves student's swimming performance (25 meter front-crawl race-performance) to a higher level compared to a "traditional" teaching scenario (control group).

In addition, two second-tier hypotheses emerged out of the study's objectives:

- H3: It was predicted that there is no gender difference regarding students' race-performance results in neither group (experimental group and control group).
- H4: It was predicted that integrating a tablet via the technology-enhanced feedback teaching-scenario in the swimming pool-based PE environment is feasible.

Hypothesis H3 is based on the assumption that at the participants' age, and swimming experience level and proficiency, gender differences in swimming performance shouldn't be significant. This assumption is backed up by several research findings (Rüst, Rosemann & Knechtle, 2014; Vaso *et al.*, 2013).

3.3 Study Design

In a pre-/post-test design, two 5th grade PE swimming classes of a German secondary school were randomly assigned experimental group (n=16) and control group (n=15). Experimental group students were exposed to a standardized video analysis and feedback program using a tablet computer. A trained PE teacher administered the program, which lasted for seven weeks. The tablet-computer-enhanced video-feedback teaching-scenario contained video feedback after diverse swimming exercises in the swimming pool during PE class as well as classroom sessions providing theoretical background and content. For instance, experimental group students were given feedback using slow motion right after their individual front crawl performance.

The PE swimming class that was designated control group didn't integrate any media and technology at all. Only "traditional" teaching methods such as verbal feedback and teacher explanations were applied.

3.4 Methods

For both experimental group students and control group students, front crawl performance under competitive race conditions (elapsed time for 25 meters) was measured at baseline (before the teaching scenario was administered) and after the teaching scenario ended (after the seven weeks class period).

The front crawl was not featured in the PE swimming classes prior to this study, whereas both PE swimming classes have covered the breaststroke.

Swimming style selection was based on the rationale that in favor of a valid research design, participants should be on the same experience and performance level at the beginning of the teaching scenario. As the breaststroke style is common as first swimming style to be learned by beginners (Barth & Dietze, 2004), front crawl was selected for this study, because it shares the same face-down position as the breaststroke to have a common basis to learn the front crawl.

The race-performance setting was chosen to generate a quantifiable measure, and was based on the direct relation of swimming technique and swimming speed, as a better swimming technique usually leads to swimming faster (Maglischo, 2003).

The race length of 25 meters is simply based on the length of the swimming pools' swim lanes, as they were only 25 m long in this case. This distance also suspends endurance, exhaustion, and turn technique as potential confounders.

Independent samples t-tests were used to analyze group differences in students' front crawl performance, as the sample showed normal distribution according to Kolmogorov-Smirnov testing.

In addition, selected students of the experimental group were surveyed regarding their perceptions towards the experienced application of tablet-based feedback in PE swimming class, using semi-structured interviews. The interviews consisted of the following questions:

- How do you rate the video feedback via tablet in this swimming class?
- Do you want video feedback via tablet to be used more frequently in PE?
- Did you experience any (technology-enhanced) video feedback in PE or sports prior to this swimming class?

Basically, the semi-structured interviews relate to hypothesis H4 ("It was predicted that integrating a tablet via the technology-enhanced teaching feedback teaching-scenario in the swimming pool-based PE environment is feasible"), as they allude to feasibility of tabled-enhanced video-feedback in swimming classes from the students' perspective.

Due to the interviews being relatively short in length, the interviews were transcribed and analyzed according to relevant statements in order to get information about how the students judged the tablet-enhanced teaching scenario feasible or not.

4 Results

4.1 Race Performance

Experimental group students improved in front crawl racing-results from pre-testing (M=33.39 seconds) to post-testing (M=31.19 seconds) statistically significantly ($p<0.05$). Control group students improved only slightly from pre-testing (M=39.56 seconds) to post-testing (M=38.53 seconds). There were no statistically significant differences between experimental group students' base levels and control group students' base levels at baseline ($p>0.05$). Table 1 shows the 25m front crawl race performance pre-post group comparisons.

Table 1
25M FRONT CRAWL RACE PERFORMANCE PRE-POST GROUP COMPARISON

Group	25 m front crawl race		
	Pre (SD) (seconds)	Post (SD) (seconds)	Pre-post difference (seconds)
Experimental group	33.39 (9.43)	31.19 (6.85)	-2.2*
Control group	39.56 (8.35)	38.53 (8.68)	-1.03

Note. * = significant at the $p < 0.05$ level. Values are means. m = meters.

Table 2 displays the experimental group descriptive study results. Table 3 displays the control group descriptive study results. Both tables list each student's performance pre- and post-program, as well as pre-post difference. Student names were anonymized.

Table 2
EXPERIMENTAL GROUP DESCRIPTIVE STUDY RESULTS

Name	Gender	Pre (seconds)	Post (seconds)	Pre-post difference (seconds)
Luna	f	55.72	36.76	-18.96
Sarah	f	36.02	31.71	-4.31

Name	Gender	Pre (seconds)	Post (seconds)	Pre-post difference (seconds)
Eve	f	26.74	25.16	-1.56
Francine	f	30.42	29.04	-1.38
Madita	f	46.39	45.37	-1.02
Annabell	f	33.83	34.22	+0.39
Laura	f	28.59	29.11	+0.52
Steven	m	45.55	40.92	-4.63
Merlin	m	27.09	24.43	-2.66
Tim H.	m	38.24	36.32	-1.92
Moritz	m	31.59	30.06	-1.53
Tim B.	m	29.88	28.53	-1.35
Leon A.	m	18.39	18.25	-0.14
Simon	m	22.63	23.28	+0.65
Robin	m	33.66	34.63	+0.97
Finn	m	29.45	31.19	+1.74
Note. n=16. f=female. m=male.				

Table 3
CONTROL GROUP DESCRIPTIVE STUDY RESULTS

Name	Gender	Pre (seconds)	Post (seconds)	Pre-post difference (seconds)
Kim	f	51.36	43.68	-7.68
Zuzanna	f	54.42	53.87	-0.55
Lea	f	44.61	44.95	+0.34
Jana	f	32.49	33.73	+1.24
Helena	f	44.71	50.5	+5.79
Quentin	m	38.86	31.95	-6.91
Marcel	m	38.59	31.76	-6.83
Jonas	m	34.85	29.82	-5.03
Christian	m	31.65	26.91	-4.74
Felix	m	52.83	49.87	-2.96
Can	m	27.59	26.51	-1.08
Jonas	m	38.52	37.6	-0.92
David	m	36.85	36.65	-0.2
Leon P.	m	35.69	41.33	+5.64
Johannes	m	30.34	36.81	+6.47
Note. n=15. f=female. m=male.				

Descriptively, boys swim faster than girls in general. Experimental group boys improved in front crawl racing-results from pre-testing (M=30.72 seconds; SD=8.05) to post-testing (M=29.73 seconds; SD=7.05). Experimental group girls also improved in front crawl racing-results from pre-testing (M=36.82 seconds; SD=10.56) to post-testing (M=33.05 seconds; SD=6.62). Moreover, experimental group girls improved to a much greater extent (M=-3.77 seconds) compared to experimental group boys (M=-0.99 seconds). However, there were no statistically significant differences between experimental group boys and girls at baseline and post-testing ($p>0.05$).

Control group boys improved in front crawl racing-results from pre-testing (M=36.58 seconds; SD=6.87) to post-testing (M=35.12 seconds; SD=7.22). Control group girls also improved in front crawl racing-results from pre-testing (M=45.52 seconds; SD=8.43) to post-testing (M=45.35 seconds; SD=7.7). Control group boys improved to a slightly greater extent (M=-1.46 seconds) compared to control group girls (M=-0.43 seconds). There were no statistically significant differences between control group boys and girls at baseline. However, there were statistically significant differences between control group boys and girls at post-testing ($p<0.05$).

4.2 Interviews

Semi-structured interviews with selected experimental group students revealed that the students judged the video feedback scenario using a tablet computer being helpful and motivating for their learning process of improving their front crawl technique and eventually their race results.

Luna placed emphasized on mental imagery, when stating that the video of her own performance helped her to see exactly what she did wrong. Especially her individual improvements could be made visible in a very helping way and motivated her. Francine reported a motivational boost as well, that was reportedly not connected to final grading considerations.

Robin explicitly focused on the benefits of the tablet-enhanced video feedback compared to traditional verbal feedback. He considered the video feedback way more efficient, easier going, and motivating than traditional feedback methods.

Simon reported the video feedback was fostering his learning because he could understand the PE teacher’s cues better compared to traditional verbal feedback and could adapt faster. He praised the slow motion tool, which he deemed extraordinary useful for motor learning processes in general.

Merlin, Tim H., and Robin wished for a wider implementation of digital video feedback and analysis in PE. According to Merlin, the same feedback scenario should be applied to soccer units, whereas Tim mentioned the potential of video feedback for tactical components of sports games.

No interviewed student had prior experience with digital video analysis in the realm of motor learning in PE. However, Luna reported she used her smart phone to record a teammate's table tennis technique (fore and backhand topspin) outside school.

4.3 Hypotheses

The main hypotheses H1 ("It was predicted that a tablet-computer-enhanced video-feedback teaching-scenario (experimental group) in PE significantly improves student's swimming performance (25 meter front-crawl race-performance)") and H2 ("It was predicted that a tablet-computer enhanced video-feedback teaching-scenario (experimental group) in PE improves student's swimming performance (25 meter front-crawl race-performance) to a higher level compared to a "traditional" teaching scenario (control group)") can be confirmed by the given evidence.

Hypothesis H3 ("It was predicted that there is no gender difference regarding students' race-performance results in neither group (experimental group and control group)") can be partially confirmed/rejected, as there was only a significant difference between experimental group boys and girls at baseline and post-testing. According to the interview analysis, hypothesis H4 ("It was predicted that integrating a tablet via the technology-enhanced teaching feedback teaching-scenario in the swimming pool-based PE environment is feasible") can be confirmed.

5 Discussion

The experimental group's performance improvement (M=-2.2 seconds) is to be considered an enormous improvement, as a one-second improvement already means a clear and huge performance increase in swimming.

Differences in boys and girls' performances may be explained by biologically different physical conditions. However, as the digital video feedback scenario didn't have different effects on boys and girls, is may be concluded that this method is equally effective and beneficiary regardless of gender.

On the other hand, as control group results have shown, traditional verbal feedback methods may show different levels of efficiency regarding gender. Therefore, boys may be more prone to traditional feedback than girls. Nevertheless, these results should be treated with caution, as the number of females and males within the study group was not equally balanced. Furthermore, stages of cognitive development may have influenced motor development as well.

The fact that there were no statistically significant differences between experimental group and control group in regard to base level at baseline upgrades this study's results' significance. However, talent level was not accounted for and not assessed.

One may ask why certain students declined in performance, which could be observed in both experimental and control group (compare Table 2 and Table 3). One possible explanation could be found in the emphasis on the correct execution of the front crawl technique during the particular classes. Both 25m race results and technique execution accounted for the students' front crawl final grade.

Taking a closer look at the students' single results, Luna did improve enormously (-18.96 seconds). According to the PE teachers' assessment her front crawl technique improved enormously too. This goes well hand in hand with her statement that the digital video feedback raised her motivation to work on her technique.

Although Annabell's and Simon's values have declined, their technique has improved. This phenomenon also accounts for Robin. According tot he PE teacher's assessment, the reason for the decline may be found in the lack of stamina and endurance.

The positive feedback regarding the teaching scenario by Francine could also be confirmed by her race results improvement (-1.38 seconds). Notably, Leon A.'s improvement (-0.14 seconds) shows that even advanced students with very good baseline values can still improve.

The fact that no student has ever experienced digital video feedback prior to this unit accounts for the fact that technology and PE is still an under-researched and underdeveloped topic (Kretschmann, 2010; 2012). However, Luna's report of video feedback applications outside the school PE setting may be regarded as a sign that digital video feedback holds a substantial contribution to motor learning in general (Liebermann *et al.*, 2002).

Conclusion

Video feedback via tablet technology in PE swimming class served as a sufficient and effective teaching method for improving front crawl swimming performance in 5th grade students. The technology-enhanced video-feedback teaching scenario proved to be superior compared to traditional teaching methods and feasible in the swimming pool environment, as students deemed it a sensible and beneficiary add to PE.

Future research and teaching should continue to integrate tablet-technology and video feedback, especially in technology-unfriendly environments such as swimming pools, as they seem to eminently qualify for a successful technology integrating in PE.

Acknowledgements

Special thanks go to the PE teacher Christian Sauer for applying the tablet-enhanced video-feedback teaching-scenario and collecting the data, all students who volunteered to participate in the study, and all parents who gave permission to their child to participate.

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