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Technology-enhanced learning in sports education using clickers: Satisfaction, performance and immediacy

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ABSTRACT

The article addresses ICT in Education by describing an empirical investigation of technology-enhanced sports education. The study examines the use of clickers by 162 Judo athletes during seminars on the rules and regulations of the sport. Results are based on quantitative data collected on athletes' performances and attitudes and qualitative data from a focus group with the trainers. Findings suggest that the use of clickers is linked to athletes' better satisfaction and performance and enables the feedback loop between athletes and trainers. More importantly, the implementation with the use of clickers can simulate the fast reaction time and decision making required during a Judo battle, which is difficult to achieve without the means of technology. Research of technology in the field of sport/physical education is limited. This study provides an interesting presentation of the potential of clickers to improve training quality for both athletes and trainers.

Keywords: clickers; classroom response systems; sports education; physical education, training; technology-enhanced learning; ICT in education.

INTRODUCTION

As part of Judo education and training, athletes are taught to act as coaches making prompt decisions on battle events, which requires a good understanding of the rules and regulations of the sport. Instructional content for this type of training is designed annually by the International Judo Federation (IJF) which determines the official position on manners, conduct and arbitration rules of the sport. This instructional content is based on a rich collection of authentic video-snapshots taken from the International Judo competition. Correct decisions on the event of each video-snapshot and explanations are also provided by IJF. In a seminar on the rules and regulations of the sport, athletes typically watch the video-snapshots and elaborate on what is right or wrong in the case of the demonstrated events. The seminar either involves a class-wide discussion of the video-snapshots and appropriate decision-making or it takes the form of a typical individual assessment of athletes' understanding of the rules and regulations (i.e., a knowledge test with multiple-choice type of possible decisions the Judo coach should have made in each case). In any case, it is desirable that the athletes respond quickly and accurately to the demonstrated events, replicating the fast pace in making judgments required by a coach during a Judo battle.

In this study, the investigators (a Judo trainer and an educational technologist) sought to examine the potential value of using clickers to improve the effectiveness of Judo seminars on the rules and regulations of the sport. We would argue that, despite the richness of the IJF instructional content, the current practice of training fails to simulate the fast reaction time and decision making required during a Judo battle. Thus, we perceived clickers as a relevant technology to integrate into these seminars to simulate the fast paced nature of Judo coaching. Clickers are remote personal response systems, recorded in the literature with different names like Classroom Performance System (CRS), Clicker Assessment and Feedback (CAF) and Audience Response

Systems (ARS). They consist of a small remote control, which is accompanied by a receiver connection as well as an application for the operation of the system and the recording of results. Their use in educational settings has been found to assist the interaction between learners and instructors, support understanding of the subject of the course, allow assessment of the leaners' stage of knowledge, and enable the feedback loop between learners and instructors (e.g., Boyle & Nicol, 2003; Ioannou & Artino, 2010; Premuroso, Tong, & Beed, 2011; Roush & Song, 2013).

Furthermore, the study draws on the ideas of gamification as an educational method that sets the overall learning process as a game or competition. The term refers to the "use of game mechanics in non-gaming contexts" (Deterding *et al.*, 2011) or "the phenomenon of creating gameful experiences" (Koivisto & Hamari, 2014). The challenge is to adapt game features in a learning environment, in this case an assessment setting, without squeezing out what is enjoyable about games (Garris, Ahlers, & Driskell, 2002). There have been many attempts to implement gamification in many areas of education and training, to make learning more engaging (Ott & Tavella, 2010) and researchers have argued that gamification methods can affect learners' or trainees' motivation and interaction within a learning/training setting (Ejsing-Duun & Karoff, 2014). Also, results from tertiary education show significant correlation between the performance of students in gamified activities and their performance on a final examination (Mavridis *et al.,* 2014). We therefore, expected that clickers could gamify Judo seminars giving the trainers the chance to praise the athletes, making the seminar more attractive and potently more effective.

Overall, learning technology in sport education is not a topic we see researched very often; yet we suggest its potential to improve sports education and sport-related outcomes should not be undervalued. Our overarching goal for this work was to examine the possible comparative advantage of clicker-enhanced Judo seminars over conventional (paper and pencil) seminars, with regard to athletes' performance, attitudes, and response to the fast paced nature of Judo coaching.

Previous Studies

The last ten years have seen significant number of studies on the use of clickers in education. Most researchers agree that the integration of clickers in educational settings can enhance teaching and learning. In particular, it has been noted that the immediacy of collecting students' responses helps the instructors understand the needs of their students and potential deficiencies of the instruction, which then allows for a more effective delivery of the course. Also, the ability to see how many others have given the same answer, makes both students and instructors fully aware of the level of understanding of the course content. Moreover, the ease of use of the technology, but also the anonymity it provides, helps the students actively participate in the course without concerns about showing themselves up in front of their classmates, while in general, students experience increased satisfaction and performance with the integration of clickers in their lessons (e.g., Boyle & Nicol, 2003; Ioannou & Artino, 2010; Premuroso, Tong, & Beed, 2011; Roush & Song, 2013).

In terms of learning outcomes, Mayer *et al.* 2009, for example, found evidence that clickers can promote academic performance in large lecture classes at the college level, consistent with the generative theory of learning which proposes that students learn better when they engage in appropriate cognitive processing during learning. In their quasi-experiment, students in an educational psychology course, scored significantly higher in the exam when they used clickers to answer 2-4 questions per lecture (clicker group), compared to an identical class with in-class questions presented without clickers (non-clicker group) or with no in-class questions (control group). Similarly, a quasi-experimental study conducted by Brady, Seli & Rosenthal (2013) with a total of 198 participants from three sessions of an undergraduate educational psychology course reported higher performance outcomes when clickers were used and discussed how

metacognition from the use of clickers influenced the learning process. Furthermore, Chui, Martin & Pike (2013) examined the relationship between the use of clickers and leaners' performance with 86 undergraduate students in two classes. One class (38 students) used clickers, while the other class (48 students) served as a control group. Results showed higher in-class performance for the clickers group, although no significant differences were found in the overall course performance based on an examination test. In a slightly different learning context, Smith *et al*. (2012) worked with Raspberry growers during in seminars specialized in the breeding industry. Clickers (and clicker questions) aimed to make the seminars more productive. A total of 106 people attended these seminars, primarily farmers managing their own land, with different levels of education, experience and involvement with the agricultural sector. Clicker-type questions focused on practical examples. Results showed that participants in the clickers group answered more correct questions compared those in the control group (Smith *et al*., 2012).

In terms of attitudes, Roush & Song (2013), for example, investigated the use of clickers in six high school Spanish classes. A total of 99 students and 17 teachers responded to a survey assessing students' and teachers' views of the impact of using clickers on students' learning experiences; 43 students and 15 teachers participated in follow-up interviews. Findings from the study suggested that the use of clickers can improve students' interest and engagement in class and can provide review opportunities which, in turn, might help improve students' scores on assessments. Similarly, Ioannou & Artino (2010) studied the use of clickers in a small (33 students) undergraduate educational psychology course and found that clickers can enhance interactivity, provide just-in-time feedback to determine students' level of understanding and help to maintain attention, interest and engagement in the course. Also, in a study by Heaslip, Donovan & Cullen (2014), 120 students became more active and more attentive in the course when clickers were used. Better attendance was also recorded in a study by Baltaci-Goktalay (2016) who used clickers with 5-graders in a science and technology course. Although, there was no difference in their academic achievement, students in the clickers group reported that clickers made the learning environment more enjoyable. Llena, Forner & Cueva (2015) investigated the perceptions around the use of clickers in eight preclinical seminars in dental pathology and evaluated students' and teachers' degree of satisfaction with the technology. Students characterized the process as dynamic, participative and motivating and teachers argued that the use of clickers can improve teaching and learning. Last but not least, Oigara & Keengwe (2013) evaluated students' perceptions of using clickers as an instructional tool to promote active learning. The study involved 24 undergraduate students in a geography semester-long class. Data was collected via student interviews, student surveys, and exam grades. Although students did not find clickers to be a motivating factor, results showed that clickers promoted student engagement and helped them develop confidence due to the immediate feedback provided.

Clickers, in general, appear to work particularly well with large audiences. Boyle & Nicol (2003) for example, investigated whether clickers can be used to promote discussion in engineering classes with large numbers of students. The researchers found that the structure of the lectures using clickers gave a comparative advantage over conventional lectures, as the teachers can immediately recognize the difficulties of the students while teaching is still in progress. The researchers further discussed how the success of this method of teaching is based on the construction of effective questions, an argument also supported by Ioannou & Artino (2010). In a later study, Blasco-Arcas *et al.* (2013) attempted to theorise the use of clickers in education. The authors drew upon sound theories of student behaviour and learning as well as on empirical research findings and developed a conceptual framework in which they proposed that the interactivity with peers and the instructor resulting from the use of clickers, influences student engagement and active collaborative learning, which ultimately determines students' learning performance. These authors presented a strong support for their proposed model after testing it with 198 undergraduate students in business courses using clickers. The results are in line with the study of Sharma (2016) with 96 medical students. In this case, the use of clickers helped

students pay more attention, be more active participants during the lecture, and express their views easily. The study stated the positive effect of immediate feedback and easy evaluation. Similarly, a study by Green *et al.* (2015) reported stronger student involvement students and better learning in hospitality lecture courses. Also, the anonymous participation, immediate feedback, and engagement with the course were amongst the positive findings reported in Spark and de Klerk (2015) who examined the effect of clickers in diverse large classes at University of the Witwatersrand using a mixed-methods research design.

Unlike the positive results that many studies report, there are also some negative reportings about the use clickers. One such example is the time taken for the preparation for the use of clickers. For example, Han & Finkelstein (2013) and Kenwright (2009) explained that extra time is needed to understand the technology and prepare a good courses using clickers, which can lead to shrinkage of the curriculum (Osterman, 2008).

Despite the submental work on the use of clickers in education, their use in sports education and training has not been studied yet. Moss & Crowley (2011) argued that clickers are flexible tools and their use in the educational arena is limited only by the imagination of the teacher. As they explain, with some creative thinking, clickers can be used by a wide range of people in a wide range of settings including formal and informal learning situations. Echoing this view, we undertook this investigation considering clickers as a relevant technology to integrate in Judo training to simulate the fast reaction time and decision making required during a Judo battle. This study appears to be the first in the area of technology-enhanced sports education using clickers, offering a new perceptive on the affordances of clickers in this arena.

METHOD

Research design

This is a mix-method study that involves within-subject quasi-experimental quantitative design and focus group qualitative research method. In particular, the study used a within-subject (repeated measures) design with counterbalancing. The power of the within-subject design is that it allows the researcher to study every single participant in both treatments (clickers and paper-and-pencil). This design controls the variance due to individual differences and increases the likelihood that any differences found across conditions are the result of the treatment and not characteristics of the participants. At the end of the seminars, the investigators conducted a 60-minute semi-structured focus group with the two trainers of the Academy.

Participants

A total of N=162 athletes, in six cohorts of a Judo Academy in Cyprus participated in the study (i.e., sample of convenience). Athletes were between 7-50 years old with a range of ages in each cohort. The complete sample was composed of 70% aged 12-18 years and 30% aged 18-50 years, and the majority were male athletes (70%). Using Clickers was a first-time experience for all the participants. Participants in this study were also two trainers at the Academy and the investigators (authors) of this work, one of them being a Judo trainer. Both trainers and the investigators were present and assisted in the implementation of all six seminars.

Procedures

A seminar was conducted for each cohort. The instructional material for the training of Judo athletes was provided by IJF and included video-snapshots from the International Judo competitions. Multiple-choice type responses were designed for each video, with five possible

decisions/answers the Judo coach could have made in each case. Each seminar included 30 video-snapshots/multiple-choice questions; 15 were answered using clickers and 15 using paper-and-pencil, with a 5-minute break between conditions.

To avoid confounding fatigue effects, practice effects, or carryover effects, with the technology effect, the conditions (clickers vs. paper-and-pencil) were counterbalanced across cohorts, for example in cohort 1, participants used clickers first, in cohort 2, participants used paper-and-pencil first, as in Table 1.

Two screens were placed in the room, at points that were visible for all the participants. For each question, the first screen showed the video-snapshots. The second screen showed the possible answers to what should be the decision of the coach concerning the event. The participants sat in rows in front of the screens as in Figure 1. In the clickers condition, each student had a clicker with a pad-id (i.e., eponymous mode). In the paper-and-pencil condition the questions were administered in blocks marked with student's id and including one question per sheet as shown in Figure 1.

Table 1: *Participating cohorts and order of conditions*

Cohort 1		Cohort 2		Cohort 3	
n1=26		n2=29		n3=27	
clickers	paper& pencil	paper& pencil	clickers	clickers	paper& pencil
Cohort 4		Cohort 5		Cohort 6	
n4=32		n5=32		n6=16	
paper& pencil	Clickers	Clickers	paper& pencil	paper& pencil	Clickers

Athletes responded to each question after viewing a snapshot-video (approximately 10 seconds snapshot-video). Time for responding was restricted to 10 seconds per question, simulating the fast reaction time and decision making required during a Judo battle. In the same spirit, athletes were asked to respond only once. Clickers were set to lock the responding period to 10 seconds and to allow only for one answer to be clicked, deactivating the selections after responding. Naturally, these functionality was not possible to automatically control using paper-and-pencil, in which case the trainers reminded the athletes that answers should not be changed and immediately collected the answer-sheets after the 10 seconds period.

Using clickers all answers were automatically recorded in the system. The trainer presented the histogram of total responses and provided the correct answer. Depending on the results of the histogram -- and therefore the athletes' knowledge deficiencies -- the trainers provided feedback, from simple explanations to replaying the video-snapshot and performing demonstrations, which could last several minutes before moving on to the next questions. The same exact practice was adopted in the paper-and-pencil condition, even though the athletes' knowledge deficiencies were unknown at the time of providing feedback. The implementation and data collection lasted from one to one and a half hours per cohort depending on the feedback provided by the trainers.

Figure 1: *Implementation with clickers (top) and paper-and-pencil (bottom)*

Data collection

At the completion of the seminar (all 30 questions), a short questionnaire was administrated to the athletes. The questionnaire addressed students' experiences with eight Likert-type questions, ranged from 1 (completely disagree) to 7 (completely agree) repeated for the experience with clickers and for the experience with paper-and-pencil. Additionally, at the end of all seminars with all six cohorts, the investigators conducted a 60-minute semi-structured focus group with the two trainers of the academy. The focus group aimed to uncover what happened in the field and what was the value of the clickers (if any) from the perceptive of the trainers. Questions included: Tell me about the experience with clickers and without clickers; what were the pros and cons of each method; tell me about students' behaviour from your point of view; how this kind of assessment was different from what you have done in the past.

RESULTS

Quantitative data

As shown in Table 2, there was a statistically significant difference in athletes' scores on all items of the questionnaire in favour of the clickers condition. The effect size for the mean attitude score difference was large, based on Cohen's (1988) guidelines (d = .8 for large effect). Also, smaller standard deviations for the items referring to clickers, suggest how participants were in more agreement with one another about their clickers experience, compared to their paper-and-pencil experience.

Moreover, there was a statistically significant difference on athletes' performance [t (161) = 2.36, p = .019], with athletes finding more correct answers when they used clickers (M = 5.05, SD = 2.08) compared to paper-and-pencil (M = 4.60, SD = 2.28), although with a small effect size (Cohen's d = 0.20). Pearson's correlations between attitude and performance showed a non-statistically significant correlation, therefore a link between positive attitudes and performance in the clickers condition cannot be considered.

Table 2: *Descriptive statistics and t-test results for athletes' attitudes (N=162)*

	Questionnaire item	M (SD)	t-test Statistics (Effect Size)
Q1	The assessment experience with clickers was enjoyable.	6.10 (1.67)	t (161) = 6.87, p < .001 (Cohen's d = 0.73)
	The assessment experience with paper-and-pencil was enjoyable.	4.61(2.34)	
Q2	I would like to participate to more assessments using clickers.	5.63 (1.89)	t (161) = 6.11, p < .001 (Cohen's d = 0.70)
	I would like to participate to more assessments using paper-and-pencil.	4.10 (2.41)	
Q3	I enthusiastically participated in the assessment using clickers.	5.54 (1.82)	t (161) = 5.10, p < .001 (Cohen's d = 0.55)
	I enthusiastically participated in the assessment using paper-and-pencil.	4.40 (2.28)	
Q4	The experience with clickers was interesting.	5.98 (1.76)	t (161) = 6.37, p < .001 (Cohen's d = 0.69)
	The experience with paper-and-pencil was interesting.	4.58 (2.26)	
Q5	I was looking forward to answering the next question using clickers.	5.67 (1.81)	t (161) = 4.63, p < .001 (Cohen's d = 0.49)
	I was looking forward to answering the next question using paper-and-pencil.	4.67 (2.23)	
Mean attitude score with clickers.		5.78 (1.45)	t (161) = 7.18, p < .001 (Cohen's d = 0.80)
Mean attitude score with paper-and-pencil.		4.47 (1.81)	

Qualitative data

The focus group dataset was transcribed and coded as described in Saldana (2009). That is, we identified important words and short phrases in the raw data and labelled them as codes; then, we organized codes into themes and patterns. Coding was done by two researchers (authors) working closely together. Following an iterative coding approach (Saldana, 2009), a total of 29 thematic codes were identified until saturation was reached. These were then classified into three larger themes associated with the use of clickers in the training seminars. We report on the themes next.

Immediate feedback loop. As the trainers explained, in the clickers condition, the histogram of results helped them quickly recognize athletes' deficiencies in the knowledge of Judo regulations. This allowed just-in-time instruction on what needed to be learnt. As the trainers argued, in the paper-and-pencil condition, an immediate evaluation of the athletes' knowledge deficiencies was not possible; an impression of the results could only be achieved after the completion of the seminar when athletes' responses were aggregated manually. Therefore, just-in-time instruction targeting knowledge deficiencies was not possible in the paper-and-pencil condition. Feedback was provided just like in the clickers condition, but the knowledge of the athletes was unclear at the time. Therefore, based on the trainer's suggestions, the feedback loop between athletes and trainers was better facilitated using clickers.

Speed and immediacy. As the trainers explained, in the clickers condition, they could pre-set time restrictions in responding (e.g., within seconds), simulating the fast reaction time needed in the coaching of a Judo battle, during which decisions need to be taken within seconds. In the paper-and-pencil condition, the trainer set the same time constrains, but the implementation fall short with athletes delaying their submission of the answer-sheets and responding outside the time limits, despite the efforts of the trainers to collect the answers quickly and move onto the next question. Therefore, based on the trainer's suggestions, simulating the fast reaction time and decision making required during a Judo battle was difficult to achieve without the means of technology, in this case clickers.

***Irreversible decisions*.** The trainers argued how in the clickers condition, restrictions in changing one's initial response were automatically pre-set, imposing the need for a Judo coach to make accurate, irreversible decisions within seconds. In the paper-and-pencil condition, such restrictions were difficult to implement by the human coach. In fact, the trainers observed that quite a few athletes changed their answers, often several times, at the time trainers were rushing to collect the answer-sheets. Therefore, based on the trainer's suggestions, simulating the accurate and irreversible decisions needed during a Judo battle was difficult to achieve without the means of clickers.

DISCUSSION AND CONCLUSION

This was an empirical investigation of technology-enhanced sports education. The study examined the use of clickers by 162 Judo athletes during seminars on the rules and regulations of the sport. Overall, our results suggest a comparative advantage of clicker-enhanced Judo seminars over conventional (paper and pencil) seminars, with regard to athletes' performance, attitudes, and response to the fast paced nature of Judo coaching.

In particular, our findings suggest that the use of clickers is linked to more positive attitudes about the Judo seminar experience compared to a paper-and-pencil condition, with a large effect (d = .8 for large effect size), indicating the differences are meaningful and may have practical importance for users of clickers (Lecroy & Krysik, 2007). This finding is consistent with previous research

pointing to learners' positive attitudes when clickers were used in other contexts (e.g., Roush & Song, 2013; Heaslip, Donovan & Cullen, 2014). But why was the clickers' condition more attractive in the case of Judo training seminars? On one hand, a potential novelty effect, and therefore, athletes' enthusiastic reaction to the use of clickers, makes this finding a rather trivial one, but still informative for trainers who want to deliver more attractive seminars on rules and regulations of the sport using learning technology. On the other hand, building on the idea of gamifying the learning experience (Garris, Ahlers, & Driskell, 2002) it is possible that the histogram of responses in the clickers condition acted as a reward element, also giving the trainers the chance to praise the athletes, making the seminar more fun, which was then reflected in the athletes' positive attitudes. As Garris, Ahlers, & Driskell (2002) explained gamification is about rewards and incentives. Therefore, building on our initial idea of gamification, we can perhaps argue that clickers can gamify training in the context of sport education, although this can be true for every tool that immediately presents responses or other rewards.

Beyond student satisfaction, the study revealed some unique affordances of clickers in the context of sports/physical education. The trainers' perceptive was valuable in presenting how it was uniquely possible with clickers to (i) simulate the fast reaction time needed in the coaching of a Judo battle and (ii) simulate the need for a Judo coach to make accurate, irreversible decisions. Although some of these aspects were part of the motivation and design of the study (i.e., fast reaction time), the fact that trainers realized, reported and extended these ideas (i.e., clickers imposing irreversible decision making), confirms the potential of using clickers in this context. That is, this finding might be suggesting that the integration of clickers in sports/physical education is compatible with the requirements and the nature of many sports simulating speed and immediacy in making decisions which cannot be re-considered, especially in a coaching situation. The authors would therefore argue that there is value into investigating clickers further as a learning technology that holds promise in the training of athletes and in sports/physical education in general.

Furthermore, results showed that use of clickers allowed the trainers to provide just-in-time feedback stimulated by the histogram results which helped them realize the knowledge deficiencies of the athletes. This result is consistent with numerous previous works on the use of clickers in education arguing for the value of the technology in enabling formative assessment and evaluation of learners' understandings (e.g., Boyle & Nicol, 2003; Ioannou & Artino, 2010). Instead, in the paper-and-pencil condition, just-in-time evaluation of knowledge was not available at the time the correct response was revealed. Therefore, clickers served the feedback loop between trainers and athletes in a way not otherwise possible in this context, again suggesting the potential of clickers in sport education and training.

Last, the study showed significantly better scores concerning knowledge of the sports' regulations in the clickers' condition. This finding is difficult to explain in this context. Previous findings of better student achievement have been typically linked to the use of clickers as a formative assessment tool over semester-long courses (e.g., Blasco-Arcas *et al.,* 2013; Mayer *et al.,* 2009). In the present investigation, however, clickers were used in a single training seminar and therefore a sensible link to the athletes' better achievement cannot be made. Then, considering the non-significant correlations between attitudes and achievement, we cannot hypothesize that athletes' positive attitudes (linked to the use of clickers) was a mediator for better performance in the clickers' condition. Last, we even considered the item review literature (also known as answer changing) for a plausible explanation for this positive result. That is, we considered that athletes might have scored better in the clickers condition because of the pre-set restrictions in changing their initial response (while in the paper-and-pencil position, the answers were changed, often more than once, while the trainer was collecting the responses). In fact, literature on the effects of changing answers on multiple-choice tests has mixed findings. Some studies show an increase in the student's overall test score when answers are changed liked to metacognitive aspects of re-

considering the answer (Papanastasiou, 2015). Others, argue that it is best if examinees stay with their original answers on multiple choice tests (Linden, Jeon & Ferrera, 2011) which is more consistent with our results. Given our current dataset, we simply don't know if answer changing can explain our significant result in favour of the clickers. Overall the significantly better knowledge scores in the clickers' condition is an interesting finding that warrants further investigation in follow-up studies in this context.

Overall, this is a study of the use of learning technology in the context of sports/physical education and training. The study showed that the use of clickers in Judo is compatible with the requirements and the nature of the sport simulating speed and immediacy in making 'correct' decisions which cannot be re-considered. Also, judging by the positive results regarding athletes' attitudes and performances we can argue that the use of clickers holds promise in the training of athletes calling for more trials and research in this area. Learning technology in sports education is not a topic we see researched very often, but we should not undervalue its potential to improve sports-related outcomes in training contexts. We hope that this work will motivate further research in this area and inform practice in sports education and training.

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