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EFFECTS OF INTEGRATING VIDEO-BASED FEEDBACK INTO A TEACHING GAMES FOR UNDERSTANDING SOCCER UNIT

EFECTOS DE LA INTEGRACIÓN DE FEEDBACKS POR MEDIO DE VÍDEO EN UNA UNIDAD DIDÁCTICA DE FÚTBOL BASADA EN EL MODELO DE ENSEÑANZA DEL JUEGO/DEPORTE MEDIANTE LA COMPRENSIÓN

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ABSTRACT

The integration of video-based feedback within physical education lessons focused on Game-Centered Approaches (GCAs) may assist pupils' development of game performance. Year 8 pupils (n=34; aged 13-14 years) from a middle school in Eastern England were assigned to three teaching groups and taught a 6-lesson GCA unit of soccer. An A (treatment)-B (no treatment) crossover design was employed to examine the effects of video-based feedback on three game performance scores (GPS) from the Team Sport Assessment Procedure (TSAP; Gréhaigne, Richard, & Griffin, 2005). Group 1 (n=12) received video-based feedback for the first 3 weeks then had it removed; group 2 (n=12) had video feedback added in weeks 4 to 6 and group 3 (n=10) acted as a control group. During each lesson, teams participated in situated GCA practices, followed by a 'debate of ideas' with or without the video-based feedback. Lessons concluded with a small-sided game from which GPS data were collected. Significant interactions for condition-by-time in GPS were assessed using a two-way repeated measures ANOVA. Significant improvements were observed for groups 1 and 2 in all GPS during treatment. Group 3 displayed no significant changes. These findings demonstrate the efficacy of using video-based technology to improve game performance within a GCA unit of soccer.

RESUMEN

La integración del feddbacks mediante vídeo en clases de Educación Física diseñadas a partir de enfoques basados en el juego (EBJ), puede ayudar a los alumnos a mejorar su rendimiento de juego. Alumnos de octavo curso (n= 34; años: 13-14) de un colegio de secundaria de Eastern England fueron distribuidos en tres grupos a los que se les impartió una unidad didáctica de fútbol de 6 sesiones basa en EBJ. Se empleó un diseño cruzado A (tratamiento)-B (no tratamiento) para valorar los efectos del feedback basado en vídeo sobre tres Puntuaciones del Rendimiento en el Juego (PRJ) tomadas mediante

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el *Team Sport Assessment Procedure* (TSAP, Gréhaigne, Richard & Griffin, 2005). El grupo 1 (n=12) recibió el feedback sólo durante las 3 primeras semanas; el grupo 2 (n=12) recibió el feedback dos semanas más, entre la 4ª y la 6ª; y el grupo 3 (n=10) actuó como grupo control. Durante cada sesión, los equipos participaron en situaciones prácticas EBJ, seguidas de un "debate de ideas" con o sin vídeo-feedback. Las sesiones concluían con un pequeño juego modificado en el que se recogieron las PRJ. Se analizaron las interacciones significativas en función del momento de la evaluación en las PRJ, las cuales fueron evaluadas usando ANOVA de dos factores con medidas repetidas. Se observaron mejoras significativas en los grupos 1 y 2 en todas las PRJ. El grupo 3 no mostró cambios significativos. Estos resultados muestran la eficacia del uso de la tecnología descrita para aumentar el rendimiento de juego en una unidad didáctica EBJ de fútbol.

KEYWORDS. Teaching games for understanding; video-based feedback; technology.
PALABRAS CLAVE. Enseñanza del juego mediante la comprensión; feedback basado en vídeo; tecnología.

1. INTRODUCTION

In physical education programs there is an over-reliance on a direct instruction model where constituent parts of sports and games are broken down and techniques are practiced in isolated, decontextualized conditions where practice is unlikely to generalize to actual game conditions (Roberts & Fairclough, 2011). In this way, skills become techniques that are developed away from the context in which they are needed and are learned 'before the introduction of rules and game play' (Oslin & Mitchell, 2006, p. 627). The intention is that once these technical skills have been mastered, the learner will then be able to transfer these into a game situation. However, this direct instruction approach has been criticized on a number of levels and has displayed evidence that learners do not exhibit flexible game play techniques (Holt, Ward & Wallhead, 2006), lack empowerment and creativity in game play (Butler & McCahan, 2005), and are not prepared for the complexities of games (Holt et al., 2006; Kirk & MacDonald, 1998). Further criticisms lie in the role the teacher adopts within this approach, as they are often the primary decision-maker (Light, 2013).

The Teaching Games for Understanding (TGfU) approach was developed as a result of the dissatisfaction with the emphasis on the direct instruction model to games teaching (Bunker & Thorpe, 1982). Game-centered approaches (GCAs) such as TGfU, Game Sense, the Tactical Games Model, Play Practice etc., (see Oslin & Mitchell, 2006) do not neglect technical skill development, but place a greater emphasis on development of technical skill after game strategies and tactics have been understood. Advocates of TGfU refute the notion that quality game play cannot emerge until the core techniques are mastered a priori (Oslin & Mitchell, 2006), and instead, offer a way of linking techniques and tactics with the aim of promoting skillful and intelligent performance. GCA lessons begin by locating learning within modified games or game-like activities, presenting the game first and introducing technical skill practice second and when needed. The different learning environment created by the teacher further enables

them to 'step back, observe, and critically emphasize questioning to stimulate thinking and interaction' (Light & Mooney, 2014, p. 2-3). The aim of this is to guide the pupils about the various ways of overcoming the tactical problems set by the game, and understand 'why' certain skills were needed to elevate game performance.

With the advent of GCAs, the way pupils are assessed has been re-considered as new theoretical perspectives have emerged. Early research in GCAs was focused on 'which method is best' comparative research designs that was aligned to the information processing theoretical perspective. This, arguably, did little to advance research surrounding the 'effectiveness of GCAs' for meeting the learning outcomes for which they had been designed (Kirk, 2005). Theoretical perspectives such as constructivism and situated learning have underpinned more recent research with GCAs (for example Gréhaigne, Caty & Godbout, 2010; MacPhail, Kirk & Griffin 2008). The broadening of the theoretical perspectives have conceptualized learning in games as active, relational, co-constructed and permitted alternative research agendas through this consideration of learning as embodied and situated irrevocably within a social and cultural world. Thus, there is a need for research to capture this embodied cognition (also referred to as enacted knowledge) where 'movements of the body are the grammar of the game' (Light & Fawns, 2003, p.162) and knowing is inseparable from doing.

Alongside the work of the scholars noted above, Gréhaigne, Godbout, and Bouthier (2001) suggested that in order to better understand how decision-making skills evolve in game play action, consideration must be given to more than just game play performance. They stated that verbalization can be considered observable information about cognitive processes, and overt verbalization can be used as a tool for teachers and pupils to collect information about their thought processes. This verbalization can then be used as a tool for eliciting reflection and critical thinking about performance to bring transformation to action play. Taking this work forward, studies by Mahut, Chang, Nachon, Chevalier, and Gréhaigne (2003) and Wallian and Chang (2007) integrated pupils' reflection on action via verbalization to formulate a set of 'action rules' (i.e., exploiting space in attack, challenging opponents progression in defense) which 'contribute to comprehension and selection in terms of motor competencies' when playing games (Gréhaigne, Richard, & Griffin, 2005, p. 50).

The constant iterations between game play and reflection on action via verbalization (which may not be supported by statistics generated by observers using analyses from the Team Sport Assessment Procedure; Gréhaigne et al., 2005) enables performers to bring aspects of the game to a conscious level and examine their own, and each others, interpretations of game play through a 'debate of ideas' (Gréhaigne et al., 2005). This 'debate of ideas' (i.e., collaboration via social reflection and discussion) also allows the performers to link the on-going events in the game to tactical solutions in order to validate the most appropriate game play solutions and set action plans, based on action rules from the previous iterations of game play. During each tactical timeout teams participate in a 'debate of ideas' in order to review performance regarding what happened, considering strengths and weaknesses of this previous bout of game play action and so that teams can agree an 'action project' for the next bout of game

play. In this framework, there is a clear notion linking reflection and action, as well as dialogue, debate and discussion amongst the pupils to promote 'learning games through understanding' (Gréhaigne et al., 2010).

Use of Technology and Video Feedback in Physical Education

In line with technological advancements, a number of school subjects have incorporated some technology-based methods in order to improve the learning environment. For example, in physical education the National Association for Sport and Physical Education (NASPE, 2009, p. 5) state that 'Implementing technology appropriately into physical education can enhance teaching and learning and contribute to providing a quality physical education program' so as to 'help students becoming physically educated individuals who have the knowledge, skills and confidence to enjoy a lifetime of physical activity'. A survey of 114 teachers in the Mid Western District Association of the American Association for Health, Physical Education Recreation and Dance by Woods, Goc Karp, Hui & Perlman (2008) found that these teachers perceived the benefit of technology use to be threefold: first, for aiding the visual learner; second, for facilitating individual development, and third, for student assessment.

In support of the aforementioned findings, researchers have noted how the advent of technologies such as tablet devices has made it more manageable for teachers to use digital video within the classroom because the technologies are more manageable for teachers because the technologies permit the easy turnaround and provision of augmented feedback of information (Hughes & Franks, 2008) to elevate levels of performance (Banville & Poliki, 2009; Hill, 2014; Rink, 2014). This feedback can also be provided from various sources, such as the teacher, a peer or through self-assessment (Casey & Jones, 2011; NASPE, 2009).

The use of video-based technologies is one of the frequently cited technologies that teachers and researchers suggest may have the most impact within physical education. For example, individual skill development (Woods et al., 2008) can be facilitated through teachers and students' use of slow motion (Banville & Poliki, 2009) as well as live capture and instant replay (Harris, 2009). In addition, Casey and Jones (2011) found that the use of video-based technologies assisted with students' deep understanding of content being taught through the development of dialogue and self/peer reflection on skill performance. Blomqvist, Väntinnen & Luhtanen (2005) reported a further increase in the performance of tactical decisions and skill execution by offering a video based skills test prior to participating within a game. In sports coaching contexts, Groom, Cushion & Nelson (2011) further this notion by Blomqvist et al. (2005) highlighting the significance of video performance analysis as a teaching tool due to the detailed and clear nature of a player analyzing their own performance. These authors emphasize that the use of video feedback can cause alterations in behavior due to a change of knowledge and an expanded understanding of individual contribution. Finally, Groom et al. (2011) note that video analysis can have great effects on confidence as performers, through self-reflection, can often focus on the negative aspects of their performance especially when errors are involved. The use

of video can reinforce the positives within an individual or teams' performance. Hill (2014) supports this assertion, arguing that the integration of technology within educational contexts can result in increasing student autonomy and, thus, encouraging a learner-centered teaching environment (see Hill, 2014).

Notwithstanding some of the clear benefits of some video-based technologies, there remain a number of key challenges for teachers. For example, finance, training and lack of time were some of the key reasons cited by teachers in the study by Woods et al. (2008). In addition, Casey and Jones (2011) noted challenges with preparation time and time needed to ensure that the system being used worked, as well as the need to ensure the pupils did not get lost in the 'marvel' of the technology (p. 55) and consequently forget the need to learn the content being taught by the teacher.

One further challenge for teachers noted by Perlman, Forrest and Pearson (2012) was the assertion of the lack of empirical attention paid to the integration of video-based technologies to teach pupils about tactical awareness when playing games. They noted that while there were numerous practitioner articles on technology integration and the use gaming technologies within fitness related components and the benefits of this (e.g. Banville & Poliki, 2009), there were few reports of studies that paid attention to teaching tactics within a physical education context. Perlman and colleagues' case study of five 'experts' in physical education pedagogy who engaged in a weekly 45-minute game play session for a total of 14 weeks using the Nintendo Wii gaming console demonstrated that gaming technologies provided these participants with increased opportunities for cognitive understanding (i.e., decision-making). Although these findings were positive, Perlman et al. (2012) noted that some 'dissonance between execution of sport specific skills between authentic…and virtual games' (p. 91), as well as a degree of restrictiveness where the 'gaming technologies controlled certain movement of the players with little involvement of the participant' (p. 92).

Irrespective of some of the aforementioned challenges, there is clearly scope to investigate the potential benefits of video-based feedback on tactical learning and development, and how video-based feedback affects game performance outcomes within a physical education context. The benefits of adding video technology to the learning process within games and GCAs is supported as Gréhaigne et al. (2010) who argue that "the use of video films and debates-of-ideas, and soliciting mechanisms acquired during practice, is likely to facilitate the acquisition of these operations and their re-utilization in actual game play" (p. 266).

Therefore, the integration of video technology within lessons focused on the development of pupils' game performance/understanding has the potential to be a realistic and significant advancement in the games-centered physical education literature, provided the application is thorough and considered. To date, there are limited studies that have attempted to utilize video-based feedback within a GCA-focused physical education unit. For example, Koekoek and Walinga (2014) recently outlined how they used video-based technologies to enable Physical Education Teacher Education (PETE) students to develop observation and analysis skills which they could then translate to school children during basketball game play. In addition Leysen,

Dehandschutter & Aserbyt (2014) examined the use of the 'easy tag' iPad application to support the learning of coaching skills coaching skills of second year PETE students in a 3 vs. 3 basketball game. These authors noted that coaches who used an iPad gave more corrective feedback than those who did not and that coaches using the iPad application also coached more accurately during time-outs. Aside from these studies, there is a dearth of research in this area, which is surprising given the current availability and affordability of video-feedback technologies. Consequently, the purpose of this study was an attempt to establish the potential effects of integrating video-based feedback into a TGfU soccer unit to determine whether this would have any positive bearing on pupils' game performance.

2. METHODS

Participants and Setting

The population of this study consisted of 34 male pupils aged 13-14 years, from three separate classes at middle school in eastern England. The pupils in the study were of mixed ability and had varied experiences of soccer before the unit commenced. The school has government awards of recognizing their achievements within physical education and offers physical education to all pupils through fifty-five minute lessons once a week. This time includes pupils dressing down and the teacher taking roll, and also includes the management instructions of the lesson structure. The lead teacher of the unit was the same for all three groups, and had taught all the pupils since they arrived at the school aged 10. The lead teacher had over 20 years soccer coaching experience and possessed National Governing Body (NGB) certifications in both coaching and refereeing soccer. The lead teacher had also attended numerous workshops on delivering TGfU through student teacher mentor training held at a local university that had a long-established physical education teacher education program. These workshops covered the rationale of GCAs such as TGfU as well as the design of lesson episodes and units using TGfU. The second author supported the lead teacher with the integration of the video-based technology within the unit. He also possessed a NGB soccer coaching certification and several years of youth soccer coaching experience; he had developed knowledge of TGfU from participation in a second year degree unit focused on TGfU. This unit included theory and empirically based readings around GCAs such as TGfU and practical demonstrations and microteaching experiences using TGfU. It further included material regarding fidelity to model benchmarks as outlined by Metzler (2011). Written pupils assent and parental consent were ascertained prior to study commencement after prior university ethical approval.

Intervention

Within the structure of the schools normally scheduled lessons, a unit of soccer taught using a GCA, specifically TGfU, was incorporated using the schools' turf fields. The pitches were standard sized 5-a-side courts (25 x 20m) and used portable goals (2.44 x 1.22m). Standard five-a-side soccer rules were applied, although no overhead height rule was applied. The lead teacher and the second author therein agreed the content

of the soccer unit and each of the lessons ahead of their delivery. The prominent theme for learning throughout the unit was focused upon maintaining possession and preventing possession (Hastie, 2013). The manipulations within the game format were aligned to the pedagogical principles of the TGfU model (Werner, Thorpe & Bunker, 1996) and included the representation and exaggeration of full game forms, while allowing the opportunity for the lead teacher of the unit to alter the tactical complexity of each task as needed independently of the second author. The underlying offensive skills developed within this theme included passing, pass selection, off-the-ball movement and support and receiving the ball; defensive skills included positioning to intercept and win the ball.

Fidelity of Intervention

All lessons were delivered through TGfU and fidelity assessed using benchmarks cited by Metzler (2011) to ensure that lessons were implemented correctly and were not detrimental to learning outcomes. The second author was present at each physical education lesson to assess the lead teacher's fidelity to model benchmarks. Lesson plans were obtained prior to lesson implementation to ensure lessons followed the characteristics of the TGfU model. For example, the second author checked lesson plans for deductive questions and that the lead teacher organized learning tasks with the central focus on the tactical problem of maintaining possession/preventing possession. During the activity, the second author monitored the lead teacher's use of deductive questioning to develop pupils understanding of the tactical problem and ensure that games were developmentally appropriate to engage the pupils. All benchmarks were assessed positively, thus, all lessons were deemed reflective of TGfU.

Design

For the purposes of this study pupils were defined within three separate groups. Within these groups, and to control the measures of performance from external variables, pupils were divided into six evenly balanced teams (two per group), with teams remaining the same (akin to the Sport Education model) throughout the study. As Metzler (2011) states, this approach creates managerial control allowing the minimization of external factors. To further provide support for the findings and to triangulate the data, the persistent nature of the learner's groupings allowed for consistent opposition and provided the opportunity for a control group to establish an accurate baseline measure of performance. To establish balanced and even teams, a pre-test with the pupils was conducted where they were evaluated on their tactical and technical abilities. Baseline scores were attained using the same methods and assessment procedure that was implemented throughout the study at each time point to ensure factors such as fatigue did not have an influence on the data sets (see procedures for data collection below).

Teams 1 and 3 (n=12) included all pupils that received video feedback first then had it removed. Teams 2 and 4 (n=12) included pupils that received no video feedback initially but had it added during the TGfU unit. Teams 5 and 6 (n=10) were control groups who received no video feedback throughout. The team selected for analysis was

based on an A-B behavioristic model where one team (e.g. Team 1) received treatment for the first 3 weeks then had the treatment removed for the final three weeks. Thus, when Team 1 received the treatment, the opposition team (i.e., Team 2) did not receive treatment. This situation was then reversed so that Team 2 received the treatment for the second 3 weeks of the intervention and Team 1 did not. This was repeated with Teams 3 and 4, while 5 and 6 acted as controls, receiving no video feedback at any point in the study, so as to act as a reference group for the potential effects of the video feedback on Teams 1 through 4.

Cooper, Heron and Heward (2007) state that through measurement procedures it is possible to establish if, and by how much, behaviors change although this cannot reveal why or how the change occurred. By incorporating within the structure of this study the behavioral analysis techniques discussed by Cooper et al. (2007) it was hoped that reliable relations between behaviors and the independent variables could be demonstrated so as to validate the overall findings of the study. The manipulation of variables between the groups was conducted using a treatment/removal (A-B) method. This was conducted by introducing the first two teams to an additional video footage feature to analyze and display a visual representation of the feedback; before removing it and offering it to another two teams. The data gathered from this was then used to analyze the overall effects this had on performance. Cooper et al. (2007) support the assumed change caused with the introduction of a variable and state that if the variable had not been applied the data would not be altered. The predictive power of the response of the variable is known as the affirmation of the consequent.

Procedures for Data Collection

The pupils were assigned an area consisting of half a pitch to undertake their tactical games and practice within their teams. The pupils took part within game-centered practices formulated by the lead teacher of the unit and the second author on one of the unit's themes for twenty minutes allowing adequate time for multiple practice attempts. Once this time had elapsed, the teams selected for feedback participated in a 'debate of ideas' to discuss aspects of their performances. Due to the fact that the lead teacher of the unit could not be in two places at once, discussions within the video feedback group were facilitated by the second author who played back a video-taped record of the game play on a laptop connected to the recording equipment in order that pupils were able to highlight and discuss key aspects of their performance. This analysis focused on tactical decision making (e.g. how to move to an open passing lane in order to be available to receive a pass) to highlight strategies that could benefit the pupils within the culminating matches in which they then participated in after the 'debate of ideas' session. The lead teacher of the unit facilitated the group discussion that ensued without the video-taped record of the game play they had just participated in. Although the aim of this discussion was similar to the video feedback group, it was based purely on the group's ability to reflect on the action, without the video prompting.

Using the information discussed within the 'debate of ideas' the teams then competed in a ten-minute small-sided game (e.g. 5v5/6v6); the opposing teams remained

consistent throughout the study to display a true reflection of any potential learning improvement. Teams employed a goalkeeper with both teams alternating goalkeepers ensuring every player was provided equal opportunity to participate within the field of play so that game performance scores were not biased and representative of the various ability levels within each of the teams. The rotational patterns of goalkeepers were pre-determined to pair up players of similar ability to ensure a balance remained between the groups; these were confirmed during the pre-testing phase to maintain consistent patterns of play. No team possessed a player that classified himself as a goalkeeper.

A final time point to follow up on the pupils' progress was conducted four weeks after completion of the study; this timeframe was dictated by external factors surrounding scheduled term breaks and the ability to gain access to all groups whilst ensuring equality of time elapsed between final trial and retention testing. The pupils were exposed to the same conditions as in the pre-testing phase to control for external factors and no feedback was offered to either team. The scores were collated using the same technique as throughout the main part of the study. This final phase offers an insight to the retention effects brought on through the usage of video feedback. With the insertion of a delayed final phase; learning over a period of time may be assessed to greater understand whether any increases in performance are due to learning occurring, or whether the intervention stage has caused a onetime phenomenon (Gréhaigne et al., 2005).

Data Collection

A consistent and reliable data analysis tool was required to ensure recorded data was comparable between each participant; for this reason TSAP (Gréhaigne et al., 2005) was applied within the procedure due to the extensive research investigating the reliability and validity of this tool within school-based settings. Operational definitions from Gréhaigne et al. (2005) were utilized (see **Table I**).

Table I. *Operational Definitions for any coded variables*

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Coded Action	Operational Definition
Conquered Ball	A player was considered to have conquered the ball once they have intercepted it, stolen it from an opposition player, or gained possession from a loose ball such as recapturing after an unsuccessful shot on goal.
Received Ball	A ball was considered to be received as a result of a pass from a teammate that is brought under control.
Neutral Pass	A neutral pass is any attempted pass that does not advance the team's field position, and is either sideways or backwards in direction.
Attacking Pass	An attacking pass is any attempted pass to advance the team towards the opposition goal.
Shot	Any deliberate strike towards the opposition goal was considered to be a shot whether successful or not. The outcome of the shot was coded separately to distinguish successful and unsuccessful attempts
Shot Success	A successful shot was only recorded in the event of a goal being scored. If the shot was on target but saved by the goalkeeper this was recorded as unsuccessful.
Lost Ball	A ball was considered lost if a pass was not received or brought under control by a team-mate, if the player was dispossessed by an opponent, or the ball left the field of play conceding possession to the opposition side.

Adapted from Gréhaigne, Richard, & Griffin (2005)

The TSAP's focus on both the offensive (i.e., received balls, passes, shots, lost balls) and defensive aspects (i.e., conquered balls) of game play performance further enabled researchers to capture information related to the TGfU unit that focused on both the offensive (i.e., passing and pass selection) and defensive skills (i.e., interceptions, steals, recaptures after an unsuccessful shot or near loss to the other team; see **Table I**). Moreover, using the video recordings of game play, data were gathered on each of the three performance indicators of the TSAP seen below: the volume of play (VP), efficiency index (EI) and the performance score (PS). This version of the TSAP allowed for the emphasis to be on both 'gaining possession of the ball and disposing of the ball in a successful manner (e.g., pass to a teammate or shot on goal)', (Gréhaigne et al., 2005, p. 94), thus linking to both the offensive and defensive aspects of game play performance.

$$VP = \#\ of\ possessions\ (conquered\ balls + recieved\ balls)$$

$$EI = \frac{(passes + successful\ shots)}{(10 + lost\ balls)}$$

$$PS = \left(\frac{VP}{2}\right) + (EI * 2)$$

Using the recording equipment to review the video footage individual data were recorded for each player for each of the TSAP variables (see **Table I**) for the first five minutes of active game time. Included within the data collection was the location of the pupils interaction with the ball (where on the pitch the ball was received), the action attempted; neutral pass, attacking pass, shot and the outcome of each action pass completed, shot on/off target, goals and lost balls.

Coder Reliability

In order to further the results and ensure accuracy within the findings an inter-observer reliability test was developed into the data collection process. To establish inter-observer reliability checks were assigned during various time points within the study (n = 5), these check points were set during the pre-testing phase and in weeks 1, 3, 4 and 6 of the study. As Cushion, Harvey, Muir and Nelson (2012) state, the completion of inter-observer reliability checks promotes robust coder reliability. The checks were conducted using the video footage and gathering data from the coded game. To ensure coder accuracy a pre-testing session was recorded using the TSAP designed for the study within an alternate sporting context. This enabled coders to familiarize to the model used and develop a greater understanding of its functions. It is suggested by van der Mars (1989) that the possibility of biases or observer expectancies could have an influencing effect on the coder's judgment, this may occur when the coder is expecting to see a specific pattern emerge. In an attempt to reduce this influence the external coders were given no indication to which team had received the video-based feedback and results were compared upon completion of the coding session. It is desired that coder's responses reach a level of agreement to provide accurate findings; van der Mars (1989) suggests agreement levels of 80-85% are deemed sufficiently high when using complex observations systems, levels which were exceeded at all check points within the study.

Data Analysis

Data from the individuals within teams were summed to provide scores for three groups; group 1 (i.e., composed of teams 1 and 3 who received treatment for the first three weeks), group 2 (i.e., teams 2 and 4 who received treatment for the second three weeks) and group 3 (i.e., teams 3 and 6 who were controls and did not receive any treatment). All statistical data analysis and descriptive methods were performed using SPSS 19.0.0 software (Chicago, IL). Descriptive measurements are presented as mean ± SD for all groups. Through the use of quantitle-quantile (Q-Q) plots normality was established. Scores from five time points were used in the analysis for each of the TSAP variables (VP, EI and PS). These included baseline scores, week 3 scores (i.e., the week before group 2 received the video-based feedback) and retention test scores were used along with an average score for each condition (video and no-video) for each group, groups 1-3. For example, the three scores, one for each week during the video and no video conditions were collapsed into one score.

To quantify changes in VP, EI, and PS between conditions (i.e., video and no video) over time significant interactions (condition-by-time) were assessed using a two-way repeated measures analysis of variance (ANOVA). Significance was accepted at a level of $p < .05$. Partial eta^2 (η_p^2) was used as a measure of effect size with figures greater than .1379 considered to be a large effect, greater than .0588 a moderate effect size, and greater than .0099 a small effect (Cohen, 1988).

The interaction between condition-by-time for group 1 in VP, EI and PS and in group 2 for EI violated sphericity (Mauchly's w = .39, .45, .43, .49; p = .01, .02, .01, .03,

respectively) therefore a Huynh-Feldt correction was applied to the degrees of freedom of the *F* ratio.

In the occurrence of a significant F-value the Least Significant Difference correction was implemented to identify significant paired differences for which effect sizes (*r*) were calculated (Field, 2014). Effect sizes were interpreted using the following categories: small (.10); moderate (.30); and large (.50), (Field, 2014). Alpha levels for the follow-up tests were set at $p < .01$ due to the number of tests being performed. All data are presented in mean ± SD.

To quantify the differences between groups 1, 2 and 3 at the respective time points independent samples t-tests were performed with significance level accepted at a level of $p < .01$ due to the number of tests being performed[2]. All data are presented in mean ± SD.

3. RESULTS

Volume of Play (VP)

As group 1 began their video feedback treatment it was observed that the team displayed a constant and significant increase from the baseline testing scores (see **figure 1**). This increase highlighted that on average players within the video-based feedback groups were involved in a greater number of interactions with the ball throughout the measured matches. A significant interaction effect between condition and time was observed during the period when group 1 received the video-based feedback, $F(1.32, 14.57) = 6.26$, $p = .02$, $\eta_p^2 = .36$, with follow-up tests revealing significant differences between baseline scores, $M = 4.08$ ($SD = 2.35$) and scores during the video condition, $M = 6.47$ ($SD = 3.97$), $p = .01$, $r = .58$. During the phase of increased VP for group 1 there was no significant reduction in the VP for group 2, who these groups played against.

Figure 1. *Measured mean for the volume of play across each time point*

(next page)

[2] The only significant differences noted for the independent t-tests were for EI scores between group 2 and 3 and these are reported in the results section.

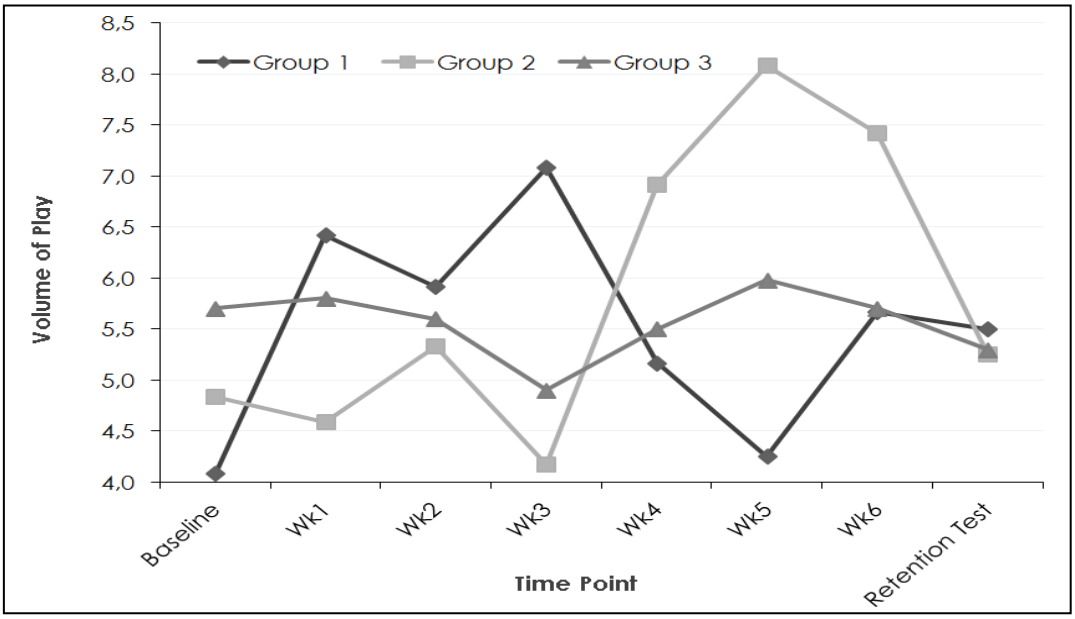

Figure 1. *Measured mean for the volume of play across each time point*

After the initial three weeks of teaching, groups 2 rather than group 1 received the video feedback. At this point the mean VP scores for group 2 displayed a sharp increase when compared to the previous three weeks as group 2 displayed no significant changes from baseline prior commencing treatment in week four (see **figure 1**). The interaction of condition and time was significant, $F(2, 22) = 7.15$, $p = 0.01$, $\eta_p^2 = .39$, with follow-up tests revealing significant differences between scores at week 3 just before the intervention commenced, $M = 4.42$ ($SD = 3.55$) and scores during the video condition, $M = 7.47$ ($SD = 4.78$), $p = .01$, $r = .58$, as well as during the no video condition, $M = 4.78$ ($SD = 3.16$), when compared to the video condition, $p = .01$, $r = .59$). Alongside this increase in group 2's VP scores, VP within group 1, on average was slightly higher than, but not significantly different to initial baseline levels. Increases for the VP performance indicator were observed from baseline within group 1, $M = 4.08$ ($SD = 2.35$) and group 2, $M = 4.83$ ($SD = 3.43$); however, no significant changes were recorded between baseline VP scores and the retention test, $M = 5.55$ ($SD = 3.55$), $p = .09$ and $M = 5.25$ ($SD = 3.44$), $p = .63$, respectively (see **Table II**). No significant changes from baseline $M = 5.70$ (SD = 3.30) were observed for group 3 at any time points including the retention test, where scores were slightly lower than baseline levels (see **Table II**).

Table II. *Percentage increase from baseline to retention test score*

Performance Indicator	**Group 1**	**Group 2**	**Group 3**
VP	34,7	8.7	-7.5
EI	8.8	18.9	6.6
PS	29.5	10.1	-4.4

Efficiency Index (EI)

In conjunction with the data for the VP it was again observed that the reported statistics for the EI increased during treatment phases (see **figure 2**). The scores then remained consistent with the baseline testing scores once treatment had ceased. For group 1, the interaction of condition and time was significant, $F(1.39, 15.26) = 4.88$, $p = .03$, $\eta_p^2 = .66$, with follow-up tests revealing significantly lower scores during the no video condition, $M = .24$ ($SD = 0.14$) when compared to week 3, the final week of the video condition, $M = .37$ ($SD = .24$), $p = .02$, $r = .54$, (see **figure 2**). For group 2, the interaction of condition and time was significant, $F(1.44, 15.82) = 6.048$, $p = .02$, $\eta_p^2 = .61$, with follow-up tests revealing significantly higher scores during the video condition, $M = .41$ ($SD = .30$) when compared to week 3, the final week of their no video condition, $M = 0.19$($SD = .18$), $p = 0.01$, $r = .57$, as well as during the no video condition, $M = .21$ (SD = .14) when compared to the video condition, $p = .01$, $r = .57$ (see **figure 2**). Although EI scores for group 1 and group 2 showed increases from baseline, $M = .25$ ($SD = .22$), $M = .21$ (SD = .19), respectively, in the retention test these were not significantly different from baseline for group 1, $M = .27$ ($SD = .19$), $p = .51$, or group 2, $M = .25$ ($SD = .18$) $p = .75$ (see **Table II**). No significant changes from baseline $M = .37$ ($SD = .31$) were observed for group 3 at any time points including the retention test, where scores were slightly higher than baseline levels, $M = .39$ ($SD = .30$), (see **Table II**). Having said that, independent samples t-tests revealed that the control group had significantly higher EI scores during the time when group 2 were not in the video condition, $M = 0.21$ ($SD = .14$) and $M = .39$ ($SD = .09$), $p = .01$, $r = .58$) and at time point 3, just before group 2 entered the video condition, $M = .19$ ($SD = .18$) and $M = .38$ ($SD = .10$), $p = .01$, $r = .56$ (see **figure 2**).

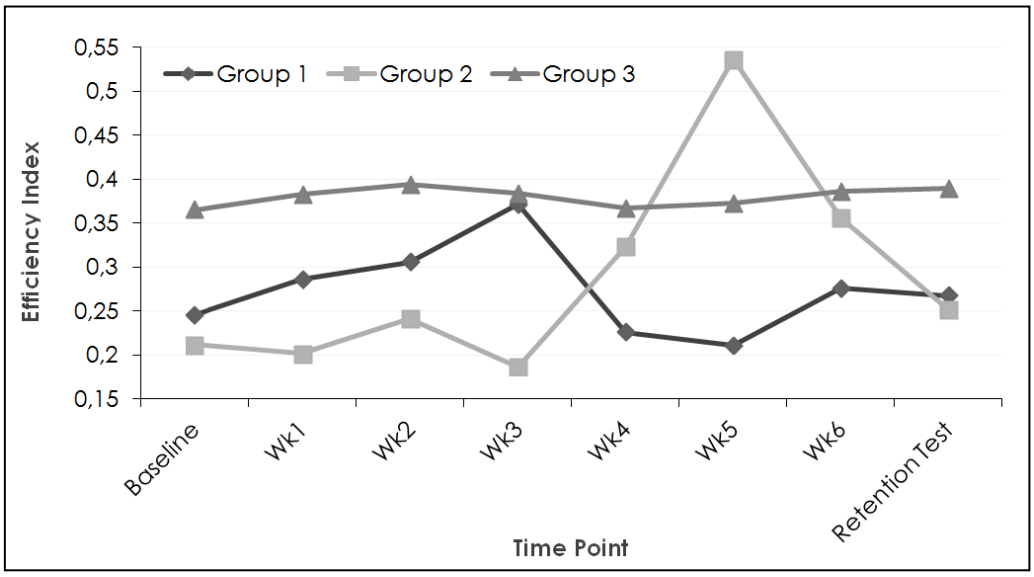

Figure 2: *Measured mean for the efficiency index across each time point*

Performance Score (PS)

As with the results from the VP and the EI there was also a similar trend with the performance scores (PS) for each team when receiving video feedback (see **figure 3**). This was because the PS displays an overall score that allows comparison between how often the learner interacts with the ball and how efficiently it is used. A significant interaction effect between condition and time was observed, $F(1.36, 14.98) = 7.08$, $p = .01$, $\eta_p^2 = .39$, with follow-up tests revealing a significant increase during the video condition, $M = 3.88$ ($SD = 2.32$) from the baseline score, $M = 2.54$ ($SD = 1.36$), $p = .01$, $r = .58$ (see **figure 3**). Within group 2 a significant interaction effect between condition and time was observed, $F(2, 22) = 7.82$, $p = .01$, $\eta_p^2 = .42$, with follow-up tests revealing significantly higher scores during the video condition, $M = 4.56$ ($SD = 2.97$) when compared to week 3, the final week of their no video condition, $M = 2.58$ ($SD = 2.08$), $p = .01$, $r = .59$, as well as during the no video condition, $M = 2.80$ ($SD = 1.83$) when compared to the video condition, $p = 0.01$, $r = 0.60$ (see **figure 3**). However, these increases for both group 1 and group 2 during the video condition did not offer any significant changes in either of these groups at retention, $M = 3.29$ ($SD = 2.12$), $p = .12$, and $M = 3.13$ ($SD = 2.03$), $p = .58$, respectively (see **Table II**). No significant changes from baseline, $M = 3.58$ ($SD = 3.08$) were observed for group 3 at any time points in the study (see **Table II**).

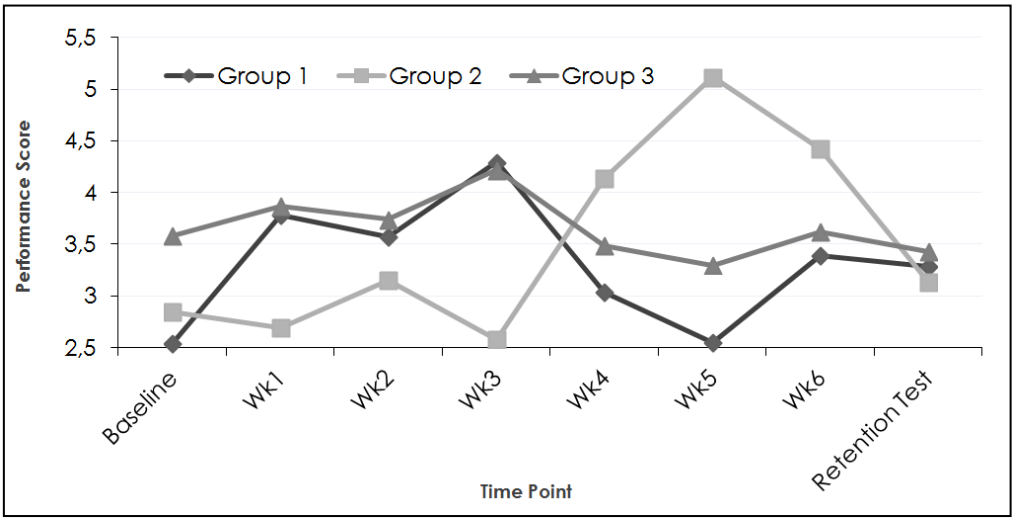

Figure 3: *Measured mean for the performance score across each time point*

4. DISCUSSION

This study was conducted in an attempt to establish the potential effects of integrating video-based feedback into a TGfU soccer unit to determine whether this would have any positive bearing on pupils' game performance. The findings suggest a strong interlinked process between the delivery of video-based performance analysis and

physical practice (Groom et al., 2011). For example, the addition of video-based feedback had a positive and substantive effect (as noted through the large effect sizes) on a number of the performance factors that were investigated, especially during the 3-week period when the groups were the specific recipients of the video-based feedback as part of their lesson. When this was introduced, significant increases in VP, EI or PS were revealed for those groups receiving the treatment. Increases in VP, EI and PS were, however, not maintained during the reversal of the treatment for group 1 (i.e., when video-based feedback was not present) and/or for groups 1 and 2 at the retention test, which was conducted approximately one month after the study.

The results of the study are positive as they indicate that incorporating video-based feedback within the 'debate of ideas' session during a TGfU soccer unit can be a supplemental tool to assist in providing feedback to participants to improve performance levels, especially in the short-term. For example, groups that received the video-based feedback not only made gains in performance as soon as this was introduced, but also maintained these higher levels of performance when it was present. Moreover, when this type of feedback was not present, the game performance of the group that did not receive the video-based feedback was not as high as it was when the video-based feedback was present. To supplement the robustness of these findings, the fact that a control group was used that received only the normal 'debate of ideas' session further assisted in establishing an effect for the video-based 'debate of ideas' for both groups that received it.

Augmented feedback has previously been shown to assist in enhancing sports performance. For example, Hodges and Franks (2008) note that one of the positive effects of feedback is that 'both knowledge of performance and knowledge of results (extrinsic feedback information) help confirm a persons own judgment about outcome success that is based on intrinsic information sources' (p. 23). The video-based feedback was certainly reflective of this notion as pupils were provided with the opportunity to analyze and interpret and self-assess their own and others performances (Casey & Jones, 2011; Groom et al., 2011), which led to performance gains due to either enhanced decision-making and/or skill execution (Blomqvist et al., 2005). Previous research has also shown that coaches using the 'Easy Tag' iPad application to code performer actions during game play also gave more accurate feedback than coaches who did not use this application (Leysen et al., 2014).

Notwithstanding these positive findings, it was apparent that there was a lack of retention of the video-based feedback by groups 1 and 2 when this was removed. This was further supported by the subsequent reduction in game performance scores in the retention test by groups 1 and 2 in comparison to their scores when they were in receipt of the video-based feedback. These findings are suggestive of a dependency between the video-based feedback and the pupils' game performance (Hodges & Franks, 2008). This dependency has been noted as a drawback to the provision of information at the end of the action sequence by previous authors (Hodges & Franks, 2008), but this is a relatively new finding in this research area because of the nature of this current study.

Hodges and Franks (2008) go on to note that 'knowing the optimal amount of feedback to prescribe can be difficult to prescribe accurately' (p. 24). Therefore future research in this area could examine how the amount of feedback and when it is delivered furthers impacts pupil's ability to retain information and transfer it to performance. These authors also suggest that dependency can be 'overcome by reducing the frequency of feedback during practice and increasing the time delay between feedback and successive practice attempts' (p. 24). One feedback strategy that could be examined is that of delayed or reduced (bandwidth) feedback, which has shown to be efficacious in the motor learning literature (Vickers, Livingston, Umeris-Bohnert & Holden, 1999). Additionally, one plausible explanation for the improvements that resulted from the groups that received the video-based feedback may have been the utilization of the second author to conduct the video-based 'debate of ideas' feedback sessions. The necessity for a second person to facilitate the video-based 'debate of ideas' can be overcome in future by practitioners taking time to train their learners to work with this technology independently of the teacher so it is not necessary that learners require the presence of a teacher to review the video footage to gain feedback on their performance (Casey & Jones, 2009).

In terms of the wider implications for TGfU practice, the integration of video-based feedback technologies provide opportunities for increasing the alignment between intended learning outcomes for TGfU (i.e. overcoming the tactical problems posed by the game) and the pedagogies associated with the learning theories that underpin TGfU such as constructivism. For example, in TGfU the teacher steps and becomes a facilitator of learning through modifying the learning environment (i.e. the game) and utilizing questioning to enhance player dialogue, debate, discussion and reflection. The use of video-based technologies clearly provide scope to further enhance the co-construction of knowledge by offering the pupils an additional lens in which to reflect on their performance in addition to that given by the teacher. The ability to analyze and reflect on performance are necessary skills in invasion games such as soccer where players work independently of the teacher/coach to make decisions on the field of play.

There are some considerations for future research as a result of this current study. First, it would possibly be advantageous to control for teacher effects within the context of the 'debate of ideas' sessions by ensuring the same teacher facilitated both the video-based feedback as well as those 'debate of ideas' sessions that did not include the video-based feedback. Second, the soccer unit needs to be conducted over a longer length of time. Integrating video-based feedback into a TGfU unit of 15-20 lessons would therefore be desirable in future studies, as has been recommended in recent studies in physical education (Ward, 2013; Hastie, Calderón, Rolim & Guarino, 2013). These longer unit timeframes would assist in developing consistency in game performance and a deeper knowledge and understanding of the action rules of soccer both with and without the video-based feedback. With this in mind, an alternative design to the A-B design employed in this study would be to conduct a multiple baseline design and/or a 'delayed' multiple baseline design. In these designs the treatment is maintained over a longer time period than the current study, and the

introduction of the video-based feedback could be 'delayed' so as to see the effects of the treatment immediately on game performance with the hope that this is 'replicated' across all groups that are introduced to the treatment (Cooper et al., 2007). This type of design is close to the 'practice-referenced', ecological designs suggested to be used by Harvey and Jarrett (2014) in their recent literature review on GCAs and by Oslin and Mitchell (2006) in their previous review. Third, and related to the previous point, it would be pertinent with this multiple baseline approach to have multiple baseline measures of the groups' performance scores rather than simply the one we collected in this current study. Fourth, to counteract the pupil's dependency on the video-based feedback, researchers could investigate using delayed or reduced (bandwidth) feedback methods into the aforementioned designs. Fifth, the intervention could be conducted with more classes and classes from different schools to replicate effects and add robustness to the argument that video-based feedback is effective within the context of a TGfU unit. Finally, the use of video-based feedback within units of TGfU in other categories of games in addition to invasion could be conducted.

What this study adds

This study has demonstrated that the addition of a video-based 'debate of ideas' within a TGfU soccer unit can improve pupils' game performance, especially in the immediate timeframe following this type of feedback. Video-based feedback also offers a means for pupils to co-construct knowledge through facilitation and support of the teacher, skills required for successful engagement in invasion games such as soccer where players work independently to make decisions. However, caution must be expressed as to ensure that pupils do not become dependent on video-based feedback to promote higher levels game performance. Practitioners need to be aware of the advantages of video-based feedback, but avoid the over-use of such feedback so that their learners do not become dependent on it. To ensure that this is the case it is suggested that practitioners consider using delayed or reduced (bandwidth) feedback strategies to prevent learners becoming over-reliant on video-feedback.

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