Reflecting on Video Feedback as a Tool for Learning Skilled Movement

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ABSTRACT
The software developer of siliconCOACH, a computerized two-dimensional video analysis tool for coaches, was assisted to reflect on how his software provided coaches with learning opportunities to understand how coaches and athletes use performance feedback. Our understanding of reflection was informed by the work of Van Manen [9] and Zeichner & Liston [10]. To assist in the reflection process, literature associated with feedback, physical education, and information & communication technology (ICT) was drawn upon. The ICT literature informed the technical reflection and had specific relevance for software development. The motor control and physical education literature informed the practical reflection and had relevance for any future development of support material to assist coaches in providing feedback to athletes. These reflections will be of interest to those coaches and sports scientists who are interested in gaining further insight into the interface between technology and coaching practice.

Key words: Feedback, Reflection, Sports Coaching, Video Technology.

INTRODUCTION

Gilbert's [1] annotated bibliography states that when the focus of the sport coaching research is on feedback, 50% of the articles have coaches as the participants, 36% focus on coach and athlete, and 14% privilege the views of the athlete. Moreover, Gilbert [1] described the design of the studies as primarily quantitative with the data gathered mainly via questionnaires.

The role that information and communication technology (ICT) has played in sports coaching has dramatically increased in a wide range of areas, including assisting in the delivery of performance feedback. Despite these developments, there appears to be little consideration given to gaining an in-depth understanding of how athletes perceive the video feedback they receive or how coaches reflect on how and/or what feedback they provide.

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During the past two decades, the focus on reflection or on becoming a reflective practitioner has gained popularity in wide variety of contexts that include education [2], graphic design [3], art [4], engineering [5], medicine [6] and increasingly in sports coaching [7,8]. It has been argued elsewhere [7] that there are numerous benefits of reflecting on one's practice. Yet, reflecting on one's practice is not an easy or quick exercise. There are many traditions, rituals and norms associated with the sport culture that act as constraints on one's willingness to experiment with becoming a reflective practitioner. This paper documents a collective process of reflecting on using ICT in the provision of performance feedback.

We report the findings of an action research process, which is a process that aims to improve participants' understanding of their practices and the context in which the practices occur. Our research group consisted of three colleagues; one is a developer of siliconCOACH (a computerized two-dimensional video analysis tool for coaches) and two are university lecturers. The focus of the project was to assist the software developer of siliconCOACH to reflect on what, and how, his software provided coaches with learning opportunities to understand how they provide, and athletes receive, performance feedback. Our understanding of reflection was informed by the work of Van Manen [9] and Zeichner & Liston [10]. Van Manen [9] argued that there are three levels of reflection: technical, practical and critical; with no level necessarily being better than another.

- *Technical reflection* occurs when the focus is on achieving objectives and on the effective and efficient application of knowledge [9,10].
- *Practical reflection* occurs when there is awareness that athletes are people not machines; that everyone involved in the coaching process brings implicit assumptions into the coaching environment and that there are practical and educational implications of an action [9,10].
- *Critical reflection* occurs when the focus is on the political, moral and ethical meaning of knowledge and the domination of various forms of authority; and occurs when questions are raised about the worth of knowledge, justice and equality and the context in which the activity occurs [9,10].

In this paper, the findings of the action research process are discussed in relation to the technical and practical levels of reflection. In relation to the technical level, the focus was on what the developer could do technologically to assist coaches effectively and efficiently provide, and athletes receive, performance feedback. The focus of the practical level was on what possible learning opportunities could be provided so coaches understand how they provide, and athletes receive, performance feedback whilst using the siliconCOACH software. These reflections will be of specific interest to those coaches and sports scientists who are interested in gaining further insight into the interface between technology and coaching practice.

siliconCOACH: A COMPUTERIZED TWO-DIMENSIONAL VIDEO ANALYSIS TOOL FOR COACHES

The orthodox process of a coach providing feedback to athletes has potential sources of error and/or miscommunication. The process may be described as follows:

1. The coach watches the performer executing a particular skill. There is potential for the coach to miss vital aspects of the movement and/or see what he or she wants to see. This could be based on past experiences and biases.

2. The coach has to translate the athlete's performance into words and/or body actions.
3. The coach then has to translate what he or she wants done into words and/or body actions.
4. The athlete has to hear and comprehend all the words and see all the body actions in the intended manner.
5. The athlete then has to use those words and actions to create internal images of him or herself doing the movement and, in turn, the way he or she should be doing the movement.
6. The athlete repeats the skill with this new information and the process is repeated.

siliconCOACH software was developed out of a research project that identified a need for a simple way for coaches to analyse human movement and give feedback to athletes on their performance (http://www.siliconcoach.com). The aim was not to get into a 'feature' war between various software companies, but to provide a practical and useful analytical tool for coaches. siliconCOACH software captures video from a standard digital video camcorder. Once the captured files are in the software, they can be presented in different ways to help coaches analyse the movements and provide feedback. On-screen drawing capabilities and measurement tools (e.g. distance, speed, angle, time) are available in order to assist in this process.

By using video analysis software such as siliconCOACH as a feedback tool, a coach can show the athlete what he or she looked like on a frame-by-frame basis compared to an expert or before/after a coaching situation. The coach and athlete can discuss what they see, plan a strategy for improvement and then repeat the process. How the feedback is presented to the athlete when using siliconCOACH is highly dependent upon on the skill of the coach. The videos can be portrayed singularly, with the coach measuring angles or looking at one body part relative to another. In addition, multiple videos can be presented on the computer screen at the same time and alongside each other to highlight (for example) where an athlete has or has not made a change in technique. In order to compare a range of situations, four video images can be put on the screen. Finally, a coach can digitise points and get a graphical representation of kinematic variables such as speed and distance.

RESEARCH PROCESS

PARTICIPANTS

Our research group consisted of three colleagues: a software developer of siliconCOACH and two university lecturers (one with an interest in pedagogy and sports coaching; and the other with interests in biomechanics and motor control). The genesis of the group was conversations on numerous occasions over the years about the need for the various parties interested in furthering the agenda of sports coaching to work together rather in isolation. The time was ripe in 2005 for the collaboration when the developer of siliconCOACH recognized that there was a need for more support material to accompany the software in assisting coaches to optimise their use of the video system. This recognition happened to coincide with a conversation between two of us in which the developer lamented that while there is an assumption that visual feedback, with or without verbal feedback, has some positive feedback on learning, little is known by the developers about how much or what type of feedback is appropriate, when it should be delivered, or even if it can be detrimental to performance in cases where it is delivered by those with inadequate knowledge. Another aspect of the conversation focused on the possibility of designing support material to assist coaches in their understanding of the feedback process. It was agreed that drawing on the literature that discusses feedback in the fields of education and motor control could contribute to increasing awareness and the development of support material.

METHODOLOGY

With a will to work together established, a framework was needed to guide the process. Action research was chosen as a methodology, as it has been described as "a form of collective self-reflective enquiry" [11, p.5]. Action research was designed for practitioners to use "in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out" [11, p.5]. A description of action research and its benefits for coaches have been discussed elsewhere [7].

The action research process comprises four phases – planning, acting, observing and reflecting – that are repeated. It was recognized that the software developer had already achieved the planning, acting and observing phases; what the research group was going to focus on was the reflection phase. According to Kemmis and McTaggart [11], the process of reflection is based upon the data that are collected and is usually fostered by discussion with others (hence the collective character of action research). Our understanding of reflection was informed by the work of Van Manen [9] and Zeichner & Liston [10] in a framework that has previously been utilized in theoretical and applied coaching situations [7, 22].

DATA COLLECTION METHODS

The data collected in this study were not the physical artefacts of siliconCOACH known to the software developer, which for commercial sensitivity will not be discussed. Rather, the data were the subsequent reflections made by the software developer on these physical artefacts (often in response to questions posed by others in the research group). The physical artefacts of siliconCOACH were also reflected upon in light of some selected literature from the fields of education and motor control that pertained to the feedback process. In the following section, we outline the literature that was drawn upon in the reflection phase of the action research cycle. In the final section of the paper, the data (i.e., software developer's reflections) are discussed.

LITERATURE REVIEW

MOTOR CONTROL

Movement analysts attempt to provide extrinsic feedback to coaches and athletes, in order to improve performance and/or to reduce the risk of injury. This extrinsic feedback augments the intrinsic feedback that is already available to performers through proprioception. Designers of video analysis packages share these aims. Until recently, coaches have been using video cameras to replay the video images and therefore cannot accurately present quantitative information such as angles to the athlete. By importing the video into the computer and using appropriate movement analysis software, variables such as angles can be measured and presented to the athlete. In addition, a 'voice-over' by the coach means they can add additional information to help the athlete understand what they are doing and what they need to do. Simultaneous and comparative presentation of visual images has also evolved, using programs such as siliconCOACH.

Although plenty of information is available for feedback, it is often unclear what should be provided or how. The use of feedback to athletes should clearly address relevant theories and empirical work from the field of motor learning and control. Some of this work is contradictory, however. Nowhere is this more important, perhaps, than in the context of whether feedback should be immediate or summary. Many sports biomechanists – and software designers – seem to assume that immediate feedback is both necessary and desirable (see [12] for example), but some motor skills research contradicts this assumption for the crucial retentive phase of

learning skill adaptations (see [13] for examples and discussion of this point).

What follows are some guidelines from existing theories and research around three key questions:

- What feedback should be provided?
- How much feedback should be provided?
- When should feedback be provided?

What Feedback Should Be Provided?

Feedback to athletes and coaches needs to be both task specific and easily assimilated by athletes. While the provision of force feedback from oar-mounted transducers is relevant to rowers, kinetic information provided to performers who are unfamiliar with it is ineffective. Therefore, video feedback can only be useful if it is related to the problem to be addressed instead of just watching the performance and trying again [12]. Video analysis tools for coaches developed over recent years, such as siliconCOACH, allow the viewing of different performances side-by-side to enable comparisons. However, it also encourages the comparison with a more skilful performer and then trying to 'mimic' that performance. Given the strong agreement among both motor learning experts and movement analysts that there is no such thing as an 'optimal movement pattern' (see [20,21]), perhaps these packages should include a warning that 'copying other performers can ruin your skill.' Therefore, the answer to the question of what feedback should be provided may be 'focus on outcomes rather than dynamics' (see [13]).

How Much Feedback Should Be Provided?

Although early theories of skill learning emphasized the provision of feedback by the coach to the performer, providing extrinsic feedback does not necessarily improve performance and may cause confusion if the information presented offers no clear solution to the problem – something coaches refer to as 'paralysis by analysis.' More recently, motor control theorists [14] have argued that the role of the coach should be to encourage the correct 'discovery environment' by manipulating the task and environmental constraints to guide the performer through the possible solutions to a particular movement problem. This has the beneficial effects of reducing the amount of information given to the performer (thus minimizing the chance of information overload), recognizing that different athletes have different solutions to the same movement demand, and providing the athletes with the opportunity to explore possible solutions that work for them. Therefore, the answer to the question of how much feedback should be provided may be that 'less is better.'

When Should Feedback Be Provided?

This question relates to the debate surrounding immediate versus summary feedback. If we have useful information to be fed back to the coach and athlete immediately, should we do so? Developers of video analysis tools such as siliconCOACH currently seek to provide video in a user-friendly way, such as with Timelapse that utilises motion picture special effects (see http://www.timelapse.com). Other video analysis tools provide video images that can be viewed immediately after a trial. Forces on bicycles and oars can even be fed back concurrently. The issue, however, is whether the provision of immediate feedback actually achieves what it is intended: an improvement in performance consequent to the training session (the retention phase) rather than just during that session. Although the motor learning literature is somewhat equivocal, there is strong evidence that summary feedback of results – provided after several trials – has a greater impact in the retention phase of skill learning

(what we want to achieve in sport) than does immediate feedback after each trial [15]. In addition, the use of augmented feedback during or immediately after each trial acts against the development by the performer of self-generated mechanisms for detection of errors [16]. This should really caution manufacturers from being drawn further down the 'immediate feedback' road, unless motor learning researchers and movement scientists can show if any positive benefits to performance can be retained. Therefore, the answer to the question of when feedback should be provide may be that 'later is better.'

EDUCATION

The practice of a coach providing feedback is not a neutral act. We draw on selected literature from education (Information and Communication (ICT) and Physical Education) to highlight possible issues concerning the inclusiveness (or not) of using video feedback as a tool for learning motor skills. In the following two sections, we discuss selected literature from the ICT and physical education fields that pertains to the software developer's reflections.

Information and Communication Technology (ICT)

In this section, we draw exclusively on Heemskerk et al's comprehensive review of literature that focused on gender, ethnic and socio-economic differences related to ICT in schools [17]. Heemskerk et al. limited their review to articles that described the participation patterns "between social groups when working with the same ICT tools" [17, p.2] because this provided insights into, among other things, "the differential impact of the characteristics of ICT as an educational tool on the learning processes and the learning results of different groups of students" [17, p.2]. Heemskerk et al. concluded that the jury is still out on the inclusiveness or educational equality of ICT. Some of the points of debate include the way the "digital divide between computer haves and have-nots…results in differences in the ICT knowledge" [17, p.1] and understanding which, in turn, may have implications for the interpretation of, and engagement with, computer-assisted video feedback. Also it has been recognized that ICT applications appeal in different ways to assorted groups of students, specifically when gender, ethnicity and culture of the groups are acknowledged. Heemskerk et al. identified how those working within the area of the sociology of technology have illustrated that technological artefacts always imply human choices; assumptions about the supposed user and the way he or she will use the artefacts are incorporated into the design [17]. Some of these assumptions concern the attitudes and interests, learning styles and prior knowledge of the users or the effectiveness of the structure and/or organization of the functions of the artefacts. A consequence of not being cognizant of the assumptions is that the "scripts" of the software package will "function unconsciously, as part of the 'hidden curriculum,'" which could inhibit the learning of particular groups of users (specifically those who cannot identify with the ideal user) [17, p.2].

In their review, Heemskerk et al. [17] grouped the literature around three characteristics of ICT applications that researchers in the field consider to be important when judging the inclusiveness of the applications: content of education ICT tools; visual and audio interface of the ICT tool; and instructional structure of an educational ICT tool. While the content of education ICT tools was considered to be important when judging the inclusiveness of the applications, Heemskerk et al. [17] noted that few scholars have empirically investigated how students and teachers experience the "gender inclusiveness" (or lack of it) and "cultural sensitivity" of ICT materials; while even fewer have explored the effects of gender inclusiveness of ICT materials on learning outcomes [17, p.3].

This raises the question for the developer in our project of whether the 'script' of the

siliconCOACH software reflects the values and mores of the various groups using the tool, or whether it is 'one size fits all.' It also raises the following question for the coaches who use video feedback as a tool for increasing an athlete's opportunity for learning motor skills: What do they know about the athlete with whom they are working and do they take this into account when, for example, choosing who to use as the expert models?

Some characteristics of ICT applications that have drawn the attention of researchers with regard to gender inclusiveness and cultural sensitivity include: the nature of icons (e.g. colour); 'navigational path' (e.g. whether a language is read vertically or from left to right); and music [17].

In terms of the instructional structure of an educational ICT tool, Heemskerk et al. [17] groups the work into three categories:

- *Prior Knowledge and Learning Strategies*: Specifically, the consideration that is given to what the users already know or how they come to know. This is relevant for the software developer in our project to consider when reflecting on the prior knowledge of the coach and is equally important for the coach when reflecting on the prior knowledge of athletes with whom they are working.
- *Collaboration and Communication*: This is particularly relevant for the coach to consider when providing feedback to the athlete. Increasingly in sports coaching, there is a move towards a guided discovery type of instruction that is associated with an increased level of questioning. Asking questions is also viewed as a way of encouraging athletes to discover a solution (a form of feedback) themselves rather than being totally reliant on the coach. Yet numerous authors have pointed out that "asking why-questions or having a different opinion from and arguing with others, particularly adults, is not a natural part of the culture of some ethnic groups" [17, p.6]. It would therefore be beneficial for coaches, who use video feedback as a tool for increasing an athlete's opportunity for learning skilled movement, to reflect on how they ask questions of their athletes and the appropriateness of doing so.
- *Instructional Structure*: When reflecting on the instructional structure of an educational ICT tool, software developers and coaches need to consider the levels of self-confidence the people they are working with have with ICT applications and how it affects the way in which the latter asks for and receives help. In discussing the literature they reviewed in this area, Heemskerk et al. [17] argue that ICT tools are often used as a means for students to work independently [17, p.7]. Due to the fact that many ICT applications are structured in a detailed way, potential problems can occur when people work with ICT applications who are not 'ideal' users and there being less opportunity for multiple interpretation of events that can occur in face-to-face communication.

Physical Education

Griffin [18] highlighted that feedback is 'gendered' by noting that feedback given to boys during gymnastics is often performance orientated (e.g., "keep your elbow high") while the feedback given to girls is more behaviour or participation orientated (e.g., "keep going," "good girl"). If the aim of the coach is to improve the skills of the males *and* females, then they need to be conscious of the feedback they are using. Providing females with verbal feedback that focuses predominantly on behaviour or participation does little to help them improve their skill level and performance [18]. Wright [19] develops this point further by highlighting that instruction and feedback is gendered by not only what is said, but also how it is said. When language patterns of two gymnastics teachers (one male, one female) were

compared, it was found that the exchange between the male teacher and males student was likely to be one way – with the male teacher constructing himself as an expert, asking few questions except to clarify organisational arrangements or to regulate athlete behaviour. In contrast, the exchange between the female teacher and the female students was comprised of the teacher giving lengthy explanations – with the female teacher using sentences joined by 'if,' 'when,' and 'because' and identifying with the students and their assumed reticence by using terms such as 'we.' Yet when the above male teacher taught volleyball to females, his language structure was more comparable to the patterns demonstrated by the female teacher teaching female students. Wright's [19] work illustrates that not only does the gender of those receiving the feedback add to the complexity of providing verbal feedback, but so does the gender of the person giving the feedback. These findings raise questions such as the following for coaches providing feedback to their athletes: How does the verbal feedback provided by the coach enable and constrain athletes to become problem solvers and decision makers? Does the verbal feedback provided to female athletes position them as being reluctant and less competent than their male counterparts?

DEVELOPER'S REFLECTIONS

TECHNICAL REFLECTION

To stimulate reflection at this level, the question posed was: What could the developer technologically do to assist coaches effectively and efficiently provide, and athletes receive, performance feedback?" When reflecting on this question, the developer commented that often the features of the software are the result of technology becoming available rather than as a result of research into what is best for the user. This is added to the fact that developers work in a commercial environment and are required to be seen as being innovative and creating new products that people will want to purchase. Research does not move as fast as the dynamic world of software development. There is often a need for developers to look at what is published, extrapolate from peripheral areas of research, and make a 'best guess' about the best features to include or exclude from the software. The developer must also achieve a balance between time, expense, knowledge of how the current technology can support particular design concepts, and what technology will be available in the near future.

When reflecting at this level, it was useful to focus on the visual and audio interface of the educational ICT tool. This characteristic is the focus of the developer's reflections since the content and the instructional structure associated with siliconCOACH largely depends on the user. When reflecting upon the interface of the siliconCOACH software, the developer mentioned that the software did not have an audio interface since all language is written (thus requiring the coach to read button names, processes and instructions). Although there is an audio input in the software, it enables a recording of the coach's words in order that there is a language common to both coach and athlete. As a consequence of the lack of an audio interface, the subsequent reflections of the developer pertain to the visual interface only. The prominent visual images on the interface are those on the icons and buttons. These are generally inanimate in nature and are designed not to be offensive. When asked what issues were considered, or what action was taken, to ensure that the visual interface was not offensive to users, the developer said that in designing it they had utilized an interface that was widely recognized and adopted by users around the world, for example Microsoft and Windows. In addition the icons and buttons are related to software function not cultural practices. Furthermore, the interface of siliconCOACH currently appears in eight languages (English, Dutch, Russian, Spanish, Japanese, German, French and simplified traditional Chinese). The software has been through six versions based on the feedback of its users and

the developers now feel they have produced a visual interface that is easy to use but still functionally powerful.

PRACTICAL REFLECTION

To stimulate reflection at the practical level, the question posed was: What learning opportunities do coaches have to understand how they provide, and athletes receive, performance feedback whilst using the siliconCOACH software? When reflecting on the possible structure of the learning session between coach and athlete, the software developer contended that it was outside his brief to provide guidance in this area. Nonetheless, he recognized the benefit of working collectively to draw on theoretical and applied knowledge to create theoretically informed guidelines for users when providing feedback in conjunction with video analysis. It was suggested that, prior to this occurring, it would be potentially useful for researchers and designers to observe and interview those coaches and athletes who were using siliconCOACH with the aim of gaining their perceptions of what using the software means to them when teaching and learning motor skills. Findings from such studies could reveal issues that have implications for the usability of the software not previously realized and potentially inform the development of educationally informed resources to support the learning opportunities whilst using the siliconCOACH software.

When drawing on the motor control and physical education literature to develop support materials for using siliconCOACH, the developer and colleagues could design the material to support coaches' understanding of what, how and when feedback could be provided; and the consequences of adopting particular feedback patterns. It may be possible, for example, to suggest feedback options for coaches who wished to assist their athletes to become more competent decision makers and/or problem solvers. Support material could be provided that discusses the implications of how much feedback is provided and the consequences of adopting particular language patterns. If coaches wished to assist their athletes to take more responsibility for their own feedback, then support material could be provided that discusses intrinsic feedback as well as the implications of what feedback is provided and the consequences of doing so.

While not specifically informing the development of siliconCOACH software, the process of reflecting at the practical level has nevertheless raised possibilities for enhancing the utilization of the software for the benefit of coaches teaching, and athletes learning, skilled movement.

SUMMARY

We have reported on the findings of an action research process, which had as its aim to support the software developer of siliconCOACH reflect on learning opportunities for coaches to understand how they provide, and athletes receive, performance feedback whilst using the siliconCOACH software. There are benefits of movement analysts, software developers, motor skill experts and educationalists working together for the benefit of coaches and athletes who use video analysis to support the learning of motor skills.

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