Integrating Technology to Enhance Athlete Development: A Literature Review

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Abstract: Everyday technologies are being developed to enhance society, solve problems, and make our lives easier and more productive. There has been a rise in technologies used to enhance sport performance, but such technologies to enhance athlete development are scarce. A Human Centered Computing (HCC) approach allows for technologies to be created specifically with the human at the center of the development to drive engagement and growth. This concept can be applied to athlete development. This literature review discusses technology solutions that are used for athletes to enhance performance and discusses various HCC topics and how they can be applied to athlete development. It will conclude by describing current technologies that are being used to address transitional skills, psychosocial factors, and health and wellness in various domains to be used as models to create technologies for athlete development.

Keywords: athlete development, human centered computing, assistive technologies

Breakthrough technology can be categorized as technology-based innovations, or market-based innovations. Technology based innovations are advances in existing technologies to improve customer relations relative to existing products and markets, such as the development of the smartphone (Liebermann et al. 2002). Market-based innovations cause departures from existing market segments by developing technologies that create new customer operations and values for emerging markets, such as introducing technology to third world countries (Christensen 1997; Zhou, Yim, & Tse, 2005). Currently, sport science has been impacted by technology-based innovations through devices developed to enhance performance, but there is little to no research on how technology can be applied to athlete development. There is an opportunity to develop market-based innovations to revolutionize athlete development strategies and interventions that assist with player and personal development.

Currently, research is geared towards developing technologies that impact sport performance. Technologies have advanced sport performance through the use of: tracking devices for sport performance enhancement, statistical tools for evaluation and feedback, and visual interactive demonstrations for analyzing replays. Tracking devices can enhance athlete performance by utilizing sensors and chips that aid in evaluating skill and movement through Computer Aided Designs (CAD). CAD systems such as multiple camera semi-automatic systems, local position measurement technology, and global positioning system technologies (GPS) are able to capture and analyze data to further research and development efforts of training and sports gear (Buchheit et al., 2014; Carling, Bloomfield, Nelsen, & Reilly, 2008). Athos Gear is one such wearable technology that monitors body biological signals through electromyography to measure muscle activity. Figure 1 is a screen shot of Athos Gear.

Figure 1: Athos Gear

Figure 1 shows the placement of sensors in the apparel. The sensors transmit data to an application and progress is tracked using a smartphone (My Athos Gear, 2016).

Analytics involve statistical data points to inform decision-making and insight for strategic planning. Statistics generate fan camaraderie, team and player commitment, and competition (Gerrard, 2016). The Australian Institute of Sport has created OptimEye, a device the size of a computer mouse that fits into the back of a jersey. It measures hundreds of data points per second of an athlete's acceleration, deceleration, jumps, and changes of direction. Figure 2 is a screenshot of OptimEye.

Figure 2: OptimEye

Figure 2 shows OptimEye being placed on the back of an athlete. Results are analyzed for performance evaluations and training programs. Through performance technologies and analytics an athlete can benefit by comparing expected optimum performance with actual movement outcome feedback (Steinbach, 2013).

Video data allows for alternate viewing options to evaluate plays to increase competition. Replay options and online interactive play create a more engaging entertaining experience for coaches and athletes, and provide more detailed evaluation for referees, umpires and officials. Skycam is a computer-controlled stabilized, cable suspended camera system that is primarily used in American football.

Figure 3: Skycam

Figure 3 is a visual of a Skycam camera. Skycam uses a stabilization system to capture video footage from multiple angles. It has a microphone to pick up on-field comments and can allow for first person viewing (Cone, 1985). Skycam, OptimEye, and Athos Gear are technologies used to assist with optimal performance and results of athletes.

There is an opportunity for technologies to emerge into a new market for athlete development. A Human Centered Computing (HCC) approach allows for technologies to be created specifically with the athlete at the center of the development to drive engagement and growth (Thomsen, 2012). This paper will give an overview of Human Centered Computing (HCC) technology research areas. This will include a definition of the technology, the theoretical foundation, and an explanation of how it can be applied to develop more effective and usable technologies for athlete development. It will conclude by analyzing current technologies that address transitional skills, psychosocial factors and health and wellness in other domains, and assert predictive outcomes where similar technologies can be developed to have an impact on athlete development.

Literature Review

Human-Centered Computing

Human-Centered Computing (HCC) puts the users at the center of design and development. HCC is an interdisciplinary field that intersects computer science, psychology, and cognitive science. HCC focuses on the design and implementation of computing systems that support people's activities and human development It is the science of designing computations and computational artifacts in support of human endeavors (Jaimes, Sebe, & Gatica-Perez, 2006). The National Science Foundation (NSF) identifies the trends of HCC research as "a three dimensional space comprising human, computer, and environment.” The NSF describes the human dimension as research that supports individual needs, through teams as goal-oriented groups, to society as an unstructured collection of connected people (NSF, 2016). HCC is focused on understanding how computational technologies affect society and how to make them more usable (University of Florida, 2016). This description of the human dimension is comparable to the athlete development literacies defined by Laboratory for Athletes and Athletic Development and Research (LAADR) in the areas of sport performance, life during sports, and life after sports (http://laadr.hhp.ufl.edu/). Placing the athletes at the center of design allows for technological solutions to be developed specifically for the athlete.

A HCC approach considers how humans understand multimedia signals at the perceptual, cognitive, and affective levels. HCC focuses on how humans interact naturally. Its design and development protocols are centered on cultural and social context as well as personal factors such as emotion, attitude, and attention (Jaimes, Gatica-Perez, Sebe, & Huang, 2007). This next section will evaluate four HCC topics. It will include a brief definition of the common methodologies, identify a theoretical foundation, and suggest a possible technology application for athlete development.

Affective Computing

Definition. Affective computing uses technology to gather information about facial expressions, posture, speech, gestures, the rhythm or force of key-strokes and temperature changes to give insight of the user's emotional state (Isbister & Höök, 2007). Affective computing relates to, arises from, or deliberately influences emotions (Daily & Picard, 2004). It is the development of systems and devices that can recognize, interpret, process, and simulate human affects. Affective computing employs algorithms for facial and emotional detection It has four core areas: recognition of human emotions by machines, affective user modeling, modeling of emotions in agent architectures, and expression of emotions in virtual agents and robots (Hudlicka & Gunes, 2012). Affective computing can be applied to computer assisted learning, perceptual information retrieval, creative arts and entertainment, and human health. One can evaluate emotional responses through a technology such as mobile electroencephalography (EEG) device (Rey, Rodríguez, & Alcañiz, 2011). Figure 5 is an example of a mobile EEG device.

Figure 4: Mobile EEG

Figure 4 displays a wearable head mount that tracks brainwave activity to track emotional responses. Emotional responses can also be determined by measuring skin conductivity, instantaneous heart rate, and heart stress entropy (Daily & Picard, 2004).

Theoretical foundation. Affective Computing is supported by the Schachter-Singer cognitive theory of emotion. This two-factor theory suggests that a stimulus leads to a physiological response that is then cognitively interpreted and labeled, which results in an emotion (Schachter, 1964). Daily (2010) uses constructionist learning and affective computing to create systems that address emotional needs.

Applied to athlete development. Affective Computing can be applied to athlete development as systems that are embedded within any player development or personal development technology. Incorporating affective computing can provide athlete development specialist, coaches, counselors and mentors with a greater understanding of the emotional state of the athlete. It can give insights to assist with psychological skills training, motivation, self-efficacy, and emotion regulation. For example, having emotional or sensory data with the personality assessments or transitional interventions can provide a more in depth, comprehensive explanation of an athletes' profile. Technology with affective computing can detect and recognize what an athlete is experiencing during trainings and intervention sessions. Information from these technologies can be used to create models to modify behaviors and create new emotions with athletes.

Adaptive and Intelligent User Interfaces

Definition. Intelligent user interfaces have the ability to accurately diagnose a user's knowledge structure, skill level, and style using rule-based parameters rather than a preprogrammed response. Within a certain domain, an intelligent user interface can apply an if-then-else rule to decide what to do next and adapt instruction accordingly (Shute & Psotka, 1994). An intelligent user interface design model should include: needs assessment, cognitive task analysis, initial implementation, and evaluation. Adaptable user interfaces use statistical inferences to create cognitive learning strategies in different pedagogical frameworks (Sonwalkar, 2007). For example, they can use case-based reasoning to adaptively change instruction methods for corrective instruction (Gilbert, 2000).

Theoretical foundation. The Zone of Proximal Development and Cognitive Learning Theory are frequently used with Adaptive and Intelligent User Interfaces. Lev Vygotsky developed the Zone of Proximal Development (ZPD) to evaluate the interaction between learning and development (Vygostsky, 1978). Adaptive user interfaces encourage scaffolding methods that are supported by ZPD. Intelligent user interfaces build on the Cognitive Learning theory that involves interaction between mental processes and information that are influenced by both intrinsic and extrinsic factors that aid in learning (Grider, 1993).

Testive system is an adaptable tutoring system based on algorithms to increase learning speed. Testive services include an online resource library with lesson plans, videos, and practice problems through an adaptive tutoring system. The Testive system was built to present content in real time that is adaptable at the students' difficulty level. Their pedagogical framework includes analogous instruction, visual modeling instruction, video instruction, reflective instruction and live instruction. Figure 6, 7, and 8 are screenshots of Testive online platform (Testive, 2016).

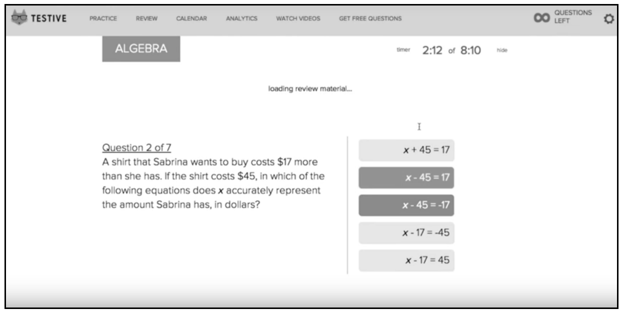

Figure 5: Student incorrectly answers on Testive

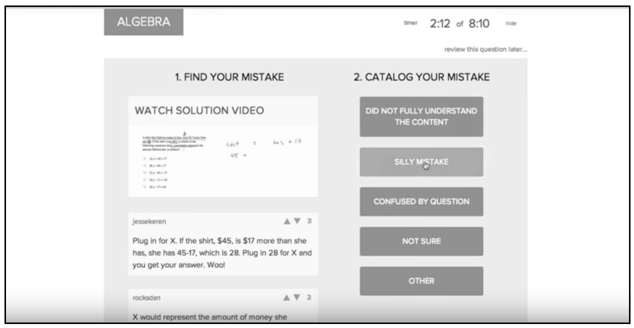

Figure 6: Student finds mistake and catalogues in Testive

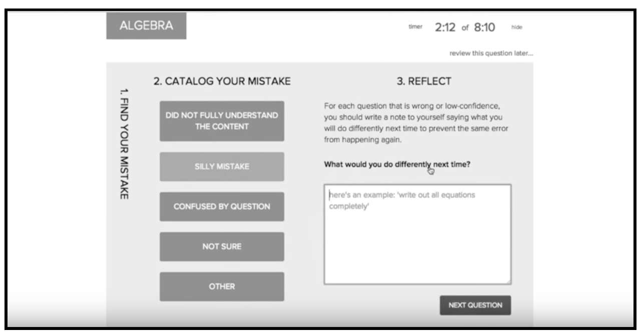

Figure 7: Student explains mistake on Testive

As shown in Figure 5, the student is presented with a problem and answers incorrectly. In Figure 6, the student is able to review the mistake, watch an instruction video, and then the system prompts the student to catalogue their mistake. In Figure 7, the student has an opportunity for personal reflection by further explaining their mistake in the text box. After they catalogue their mistake another question is given that is analogous to the one they just completed.

Applied to athlete development. Adaptive and Intelligent User Interfaces such as Testive can assist athletes in working through mental processes related to school, time management, and career transitions (Testive, 2016). Adaptive and Intelligent User Interfaces can be used to help athletes with academic affairs by providing a supportive structure that is uniquely catered to each individual. Due to rigorous schedules that athletes must undertake, adaptable and intelligent user interfaces are systems that are adaptable to each athletes learning and training progress.

Educational Technologies

Educational Technologies facilitate learning and comprehension by using technological processes and resources. Computer-supported collaborative learning encourages information sharing across networks and geographical locations. Some types of computer supported learning methods are E-learning, instructional technologies, and learning management systems (LMS). LMS can administer training content, individual instruction, and online collaboration (Forest, 2015).

Theoretical foundation. Educational Technologies use various learning theories as conceptual frameworks for how information is delivered, absorbed and retained. Learning theories draw from cognitive, emotional and environmental influences such as critical areas that affect learning (Illeris, 2004).

Applied to athlete development. These technologies can be customized to athletes by using sports as a culturally relevant pedagogy. My Sports Pulse uses culturally relevant computing to enable students to relate to course content in his or her cultural context. Metcalf, Milrad, Cheek, Raasch, and Hamilton (2008) developed My Sports Pulse, a program designed to promote student achievement and interest in Science, Technology, Engineering and Math (STEM) education. My Sports Pulse uses mobile devices to embed computational support for learning STEM concepts in the learner's physical and social context (Metcalf et al., 2008). Figure 13 is a visual of the My Sports Pulse web portal.

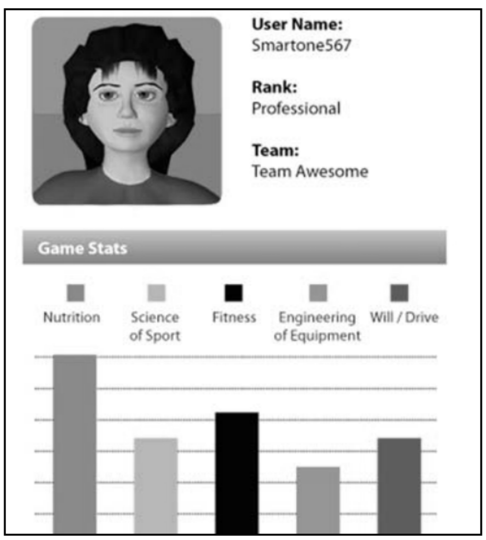

Figure 8: My Sports Pulse Web Portal

Figure 8 shows the My Sports Pulse Web Portal. The web portal tracks progress and points collected from their progress for STEM related activities. It also shows their virtual athlete avatar. The site also offers links to STEM resources for additional information. Athletes can benefit from educational technologies such as My Sports Pulse that have a culturally relevant pedagogy within a sporting context (Gilbert et al., 2008), Additionally, culturally relevant educational technologies can assist with financial literacy, health and wellness, and personal development.

Augmented and Virtual Reality

Virtual Reality (VR) is an interactive and immersive experience in a simulated three-dimensional world where objects have a sense of spatial and physical presence and can be manipulated by the user (Mazuryk & Gervautz, n.d.). Augmented Reality (AR) is used to enhance the user's perception of an interaction with the real world through three-dimensional virtual objects that appear to coexist with the real world (Azuma, Baillot, Behringer, Feiner, & Julier, 2001).

Theoretical foundation. VR and AR support constructivism. Constructivism emphasizes the combination of inputs from senses, existing knowledge, and new information to develop meaning and understanding (Chen, 1995).

Applied to athlete development. VR and AR are currently being used in sport performance, but can also be used as simulations for experiential learning and training opportunities. Athletes can be immersed in a specific environment with varying scenarios, such as Shadow Health mentioned above. Figure 9 is a screenshot of Shadow Health.

Figure 9: Shadow Health

As shown in figure 9, shadow health uses embodied conversational agents in a healthcare setting to present nurses in training with various scenarios. Athletes are not exposed to common experiences because of the demands and commitments to sport, which interfere with adolescent development. For example, college athletes do not have the everyday experiences and interactions as non-athletes to aid in the development of transitional skills. Simulations could be interventions to assist athletes with real life scenarios, career transitions, and the development of life skills.

Discussion

Existing Technology Solutions (Non Athlete Specific)

Life after sport can be a harsh reality for some athletes (Baillie & Danish, 1992). There are many intervention programs and assessments available to help athletes with transition and transferable skills, psychosocial factors, and mental health issues. Although there is limited research on technologies within athlete development, there are technologies in other domains that can be used as models and adapted for athletes. Technologies such as online personality test and career assessments are used to understand one's personality type and communication style. DiSC is a behavior assessment tool that centers on four different behavior types, dominance, influence, steadiness, and compliance. This online interactive tool is used to educate people on their behavior type and interaction temperament when working with others. DiSC is also useful for identifying transitional and transferable skills (https://www.discprofile.com).

The Center for Deployment Psychology and the Department of Veterans Affairs National Center for Post Traumatic Stress Disorders developed the Prolonged Exposure (PE) Coach mobile application. Figure 3 has 2 screenshots of the PE Coach application.

Figure 3: Prolonged Exposure Therapy Application (PE Coach)

Figure 3 shows the homescreen of PE Coach and the menu screen of PE Coach. PE Coach is a mobile app designed to help veterans cope with stress and mental health issues. PE Coach includes audio recording capability for playback after sessions, tools to support patient tasks between sessions, and visual displays of symptom reduction over time (PE Coach, 2016). Athletes can benefit from apps such as PE Coach when they have stressful experiences such as school and career pressures, sudden injury, athlete retirement, and even loss of finances.

Within the Healthcare field, nurses use virtual worlds as educational tools to train on patient interaction in various scenarios. SecondLife is a virtual world where users create avatars to interact with each other and the environment (Kidd, Morgan, & Savery, 2012). Virtual worlds allow for simulated learning experiences to give users exposures to various scenarios. Immersive learning is an experiential learning experience that athletes can use for future planning. Shadow Health Inc, an educational software company developed by Dr. Ben Lok at the University of Florida, uses virtual humans and simulations to train nurses on interpersonal skills (Robb et al., 2013). Comparing technologies in the military and healthcare fields show promise to create technologies to aid in the area of mental health for athletes.

Predictive Outcomes of Athlete Development Technologies

The previous examples of online assessments, mobile applications, and virtual reality are models of how technology is being used in various domains specifically for certain users. Similarly, technologies can be developed for athletes by using a HCC approach and athlete development principles. HCC focuses on developing technologies using a user centered approach, and athlete development is helping organizations and individuals develop the whole person to achieve success outside of sport. Athlete Development is comprised of player development and personal development. Player development is the study and practice of the factors that account for sport performance, athleticism, and sport health. Personal development is the study and practice of factors that account for athlete well being, quality of life, and success away from sport ((http://laadr.hhp.ufl.edu/).). Some athletes struggle with balance between their athletic and nonathletic abilities due to an over-reliance of athletic development and a lack of nurturing of personal development (Houle & Kluck, 2015). Since athletes are consumed with sport related activities, time has not been allocated to normal developmental events and athletes tend to identify themselves exclusively with the role of an athlete (Brewer, Van Raalte, & Linder, 1991).

Technology can help develop non-athletic abilities that are critical for success and impact personal development of athletes by using human centered computing principles. Specifically, an athlete can interact with a system that will aid in increasing capabilities in psychosocial factors through affective computing. Technology can support the development of transitional skills through adaptive and intelligent systems. There is an increase in learning opportunities by incorporating culturally relevant pedagogies related to sport in educational technologies. Technology can also expose athletes to various real life scenarios and alternative interventions through simulations by using virtual and augmented reality systems. Ultimately there are limitless technological solutions that can help define and shape the identity of an athlete, increase health and wellness, and support career transitions when they retire from sport.

Conclusion

Incorporating technologies within athlete development introduces effective, and targeted solutions for athletes' education and personal growth. Human-Centered Computing concepts such as: affective computing; adaptive and intelligent user interfaces; educational technologies; and augmented reality and virtual reality are methodologies to design technologies specifically for the user. While there are examples of technologies that can be leveraged from other fields, athletes would benefit greatly from having technologies developed for the athlete development domain. This paper is a review of how technology can be developed to create learning and developmental opportunities for athletes. Future work can model from the examples mentioned above to create market-based technologies for athlete development. The use of technologies for athlete development is an emerging field that can be impactful to athletes and their future.

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