Reconceptualizing Legitimate and Generative Learning Experiences in Sports and Technology

Tamara Clegg, University of Maryland, tclegg@umd.edu
Kareem Edouard, Drexel University, ke388@drexel.edu
Daniel Greene, University of Maryland, dgreene1@umd.edu
Stephanie Jones, Northwestern University, StephanieJones2023@u.northwestern.edu
Natalie Melo, Northwestern University, melon@u.northwestern.edu
Na'ilah Nasir, Spencer Foundation, nsnasir@spencer.org
R. Benjamin Shapiro, University of Colorado, Boulder, dude@colorado.edu
Michael Smith, Northwestern University, michaelsmith2018@u.northwestern.edu
JaCoya Thompson, Northwestern University, JacoyaThompson2020@u.northwestern.edu
Christopher Wright, Drexel University, cgw57@drexel.edu
Marcelo Worsley, Northwestern University, marcelo.worsley@northwestern.edu
Abigail Zimmermann-Niefield, University of Colorado, Boulder, abigail.zimmermannniefield@colorado.edu

Abstract: As a society, we turn to sports for entertainment, exercise and to develop general purpose skills like teamwork, leadership and communication. However, we seldom lean on athletics as a space for learning. On the contrary, sports and learning are often presented as being in conflict with one another. In this symposium we discuss ways for re-expanding perceptions of athletics as a legitimate learning context. Moreover, we surface the expansive nature of sports as a context that can touch on the cognitive, social, cultural and political elements of one's identities and lived experiences. In summary, we present and discuss examples from on-going learning sciences research that highlights the innovative ways that researchers and learners are collaborating to realize new opportunities at the intersection of sports and technology.

Introduction

Sports are a central part of the American youth experience. Every year more than 20 million children participate in one or more sporting activities. People pursue athletics for different reasons. Some parents see sports as a means to promote physical activity, and a needed response to a growing national obesity epidemic. Others see organized team sports as an opportunity to practice teamwork, leadership, sportsmanship and collaboration. Other families are encouraged by the idea that athletics can be a means to economic and social mobility. Absent among these discussions, however, is the important role that sports can play in promoting learning. Here, we do not limit ourselves to the general findings that students who regularly participate in athletics have higher grade point averages, as much of this finding is confounded with the correlation between sport participation and affluence. Similarly, we are looking beyond narratives of athletics providing access to high school and college scholarships. Instead, we consider more of the qualitative relationship between athletics and learning. Namely, athletics provides a fertile space for participants to see and experience the world differently. Importantly, we centralize how athletics can grow one's identities. Prior work in the learning sciences emphasizes this idea by framing the basketball court as a legitimate learning environment, for example. A primary objective of this symposium is to re-invigorate this discussion in the age of novel technologies. To this point, we explore the ways that sports and technology can be integrated to produce learning experiences that are deeply connected to the cognitive, social, cultural and political elements of one's identities and lived experiences.

Motivation

The motivation for integrating sports and technology is equally influenced by the need to correct a social injustice, and by a desire to better harness the opportunities that exists at this nexus. Harper, and others, bring to the forefront, the exploitative nature of college athletics, particularly with respect to African American men and women. Harper (2006) laments the disservice that is being enacted on college athletes within the most revered athletic programs around the country. Many of these programs fail to support the academic achievement of their student athletes. At the same time, people of color are seldom the ones asked to design the technologies and equipment that are used to protect them or improve their performance. Instead, consistent with stereotypical notions of Science, Technology, Engineering and Mathematics, these roles are usually filled by white men. This, then, surfaces an important opportunity for athletes, and former athletes, to be more heavily involved in the non-athletic aspects of the athletic industry. The notion of social injustice, though, also beckons the many athletes that

have used their athletic success as a platform for change. From Wilma Rudolph, to Muhammad Ali, to Colin Kaepernick, there has long been a connection between sports and politics. This is simply to say that sports contain a number of important touch points for fomenting student learning beyond across disciplines..

The papers in this symposium describe some current innovations for engaging students in generative learning around sports and technology. The symposium participants collectively identified cross-cutting themes that are core to the interventions and experiences that we design and study. The cross-cutting themes include: Identity, Embodiment/Bodies, Tools, Organizational/Institutional Structures, Political Action, Disciplinary Ideas and Sociocultural Participation.

Identity

The very term, "athlete" is one that carries with it important identity related connotations. The connotations may be internalized as a self-identity, but may also be projected. Additionally, identifying as an athlete is something that can remains a part of one's identity long after ending participation in sports. As such, a central consideration across all of the papers in this symposium, is the ways that learning at the intersection of sports and technology reflects and influences identity formation and adaptation.

Embodiment and bodies

The idea of embodiment and bodies runs through the sports domain in multiple ways. One of the canonical connections between sports and learning can be seen through the lens of Embodied Cognition, which highlights the important role that our bodies play in helping our mind understand different concepts. This is particularly the case with ideas from physics, where the students are able to embody different forces and feel sheer, for example. Less common, however, is the idea that for athletes, their physical bodies are regularly put into the service of entertainment for others. Embarking in discussion on how this profession can result in the physical deterioration of one's body, raises another important area of discussion and learning for youth.

Tools

This theme considers existing and future tools that might be used to help athletes/learners collect, analyze and reason about data. For example, collegiate and professional athletes are often instrumented with sensors that monitor their movement. Televised football games utilize augmented reality to mark a first down, and soccer uses video assistant referees to determine the validity or location of an infraction. All of these are contemporary examples of technology in sports. Beyond these, however, we consider what types of tools need to be developed to ensure that athletes are better able to learn from their data, as well as the different technological tools that would allow people to more easily design and create new athletic apparel and equipment.

Organizational/Institutional structures

Organized sports is characterized by various levels of structure. In many team sports, players are led by captains, who are tasked with engaging with a coach, or coaches. Coaches are subsequently in communication with another level in the hierarchy, leagues, divisions, and overarching governing bodies. At each level, there are important shifts in who has the agency to enact change. Simply put, different organizational and institutional structures play a significant role in maintaining the status quo. That said, institutions can also serve as the vehicle for realizing organizational change. Introducing technology may disrupt or reify these existing hierarchies.

Sociocultural participation and political action

As previously mentioned, sports remain a powerful space for realizing political action. Tommie Smith and John Carlos' raised fists in the 1968 Olympics exemplifies the global, political message that can be raised through athletics. In present day, the US Women's National soccer teams' ongoing demand for equal pay is yet another example of connecting sports with politics. Within several of the papers described here, there is an underlying goal of raising awareness and both local and national action towards equity.

Disciplinary knowledge

Conceptual knowledge and competencies in areas of math, reading, science and writing, often pose barriers to social mobility and social capital. Accordingly, one dimension of consideration for this work is developing experiences that surface the disciplinary knowledge that participants are engaging, while also elevating that knowledge. The idea of embodied cognition has many touch points to this theme, in that embodied learning experiences might translate into competencies that transfer to other spaces.

Contribution

Each paper to be presented in this symposium takes a different stance on these. In bringing these papers together, we hope to spur discussion around their commonalities and grapple with some of the challenges and tensions to centering learning experiences on sports and technology. There are important ideas to consider as it relates to how this work should be positioned relative to existing institutions, and the corresponding changes in pedagogy that need to accompany these programs. At the same time, there is the challenge of identifying measures for evaluations that appropriately reflect the theoretical underpinnings of this work. Sports is an area of the learning sciences that has been dormant for several years. However, given the current explosion and interest in technology and data science, we argue that this is an ideal time to revitalize that discussion. We suggest that the aforementioned themes could be important to positioning this research and find that this space would be a valuable conversation for the larger learning sciences community. Facilitating this discussion will be led by Na'ilah Nasir, whom many of the authors recognize as being a foundational contributor to studies on learning and sports (Nasir, 2008; Nasir & de Royston, 2013; Nasir & Hand, 2008).

Data everyday: Data analytics learning in a Division I college athletics context

Tamara Clegg, Daniel Greene, Nate Beard, and Jasmine Brunson
University of Maryland, College of Information Studies, Department of Teaching and Learning, Policy and Leadership

In the Data Everyday project, we leverage sports as a context for learning data analytics in Division I collegiate sports. Although *political action* is not a direct goal of this work, our research is motivated by broader challenges within college athletics. The low number of minorities in science and engineering professions (e.g., only 4.8% are black Americans) sits in stark contrast to the relatively high representation of minorities on high-revenue sports teams at Division I institutions (e.g., 48.4% of Division I football players and 56.4% of Division I men's basketball players are black Americans) (NCAA, 2019). While data analytics guide a number of practices within their sports play (Watson, 2014) it is unclear how much access student-athletes have to these practices, nor how they might be learning data analytics through their sports play.

Our goal is thus to empower student-athletes to be better able to make data informed sports decisions and to make more positive connections between their sports play and data analytics. We have therefore conducted interviews with student-athletes, coaches, and athletics staff at one Division I institution as a pilot study for more in-depth ethnography and design for learning. In this symposium, we will present findings from interviews with 13 student-athletes and 3 athletics staff members spanning 9 different sports at one Division I institution. Descriptions of how we position this work relative to the six overarching themes is described in the following paragraphs.

Organizational & Institutional Structures. Our interviews showed that athletes had varying levels of agency with respect to data collection and analysis influenced by the school's investment in their team. That is, students in lower-revenue sports were able to choose what to measure, how, and why in a way that peers in higher-revenue sports with expensive equipment and extensive staff were not.

Disciplinary Ideas. Building on frameworks for data literacy and data science (Maybee & Zilinski, 2015; Prado & Marzal, 2013; Shields, 2005) our findings suggest student-athletes are engaging quite authentically in multiple components of data literacy and data science – (e.g., identifying relevant data based on their needs for self-assessments, narrowing their focus from the wide range of data to specific metrics most relevant for their comparisons and self-assessments). However, athletes often need help with these analytics and do not often recognize the learning practices they are engaged in.

Tools. Our findings showed extensive use of analytics tools for sports contexts, but this is also largely guided by the university's level of engagement in the sports team. Athletes in sports that are less heavily subsidized have increased agency in determining and managing the analytic tools they will use for their sports training and performance. Conversely, those in high-revenue sports are told which analytics tools to use and data collection and analysis is heavily managed by athletics staff.

Bodies & Embodiment. Our findings indicate that in Division 1 contexts, student-athletes are keenly aware of their training data through their own felt experiences. However, their embodied experiences are mediated delicately between them and the coaches and trainers that dictate their workouts and training regimens.

Identity. Our interviews show that participants' sports identities motivated in-depth data analytics (e.g., analyses of their own progress over time and comparisons between themselves and other peer and professional athletes). Yet, the tight connection between their identities and their data also contributed to stress and pressure athletes experienced around their sports play, often driving them to step away from their data especially at high pressure moments so they could "just play."

Taken together, these findings inform next steps for in-depth observations of sports teams that will contribute to the design of analytics tools and learning experiences for student athletes and other sports-enthusiast learners.

Dressing the culture: Using sneaker culture to engage STEAM competencies

Kareem Edouard and Christopher Wright
Drexel University

Dressing the culture aims is to create and understand a model-learning environment for K-12 youth that integrates science and engineering learning, expressions of hip-hop fashion, and elements of the "SneakerHead Culture."

There is continued need for research on youth culture driven learning opportunities at the intersection of science and engineering for individuals from underrepresented communities. The integration of sneaker culture into STEAM disciplines, requires a cultural awareness of the complex relationships between students' science and engineering engagement, learning, and identity formation. Moreover, it informs our understanding of culturally sustaining structures that encourage and support participation in these disciplines.

A lack of cultural congruence has forced minority students to avoid STEM activities based on stereotypes and micro-aggressions that signal they do not belong. Minority students, for these reasons, are less likely than Caucasian students to enroll in science and engineering pipeline activities. Interest is a powerful motivator for children; indeed, a body of culturally responsive research has shown that incorporating student interest into learning helps motivate and improve student performance. With this in mind, our research aims to:

- Facilitate development of authentic agency in science and engineering among youth who identity as members of groups underrepresented in STEM fields, and youth from underestimated communities.
- Facilitate a paradigm shift from consumer perspective to producer perspective.
- Shift the *culture of informal making education* by modeling and studying culturally responsive maker spaces and curricula.

Culturally responsive scholars (e.g., Na'ilah Suad Nasir, Megan Bang, Nichole Pinkard) have been critical of the empirical approach to recruiting and supporting minoritized students in the engagement of science and engineering informal spaces. It is at this intersection of informal education fidelity and cultural modeling that Pinkard positioned the importance of meaningful culturally connected environments and curriculum constructions. To put it directly, the empowerment of minoritized students in urban communities in STEAM learning environments can be an opportunity to provide agency in bleak conditions, where students can sometimes feel powerless. We examined the integration of youth popular culture into STEAM design as an opportunity to cultivate 'disciplinary identity.'

The focus on culturally sustaining learning environments expands opportunities for young people from historically marginalized and underrepresented communities to meaningfully engage in science and engineering practices. Furthermore, by involving the intersection of youth culture, "Sneakerhead Culture." and STEAM communities, the goal is to expand cross-cultural STEAM opportunities within the fields of science and engineering education research.

Moving bodies, moving bits

R. Benjamin Shapiro, Carlie Charp, Michelle Ellsworth, Annie Kelly, Edd Taylor, Mary Etta West, and Abigail Zimmermann Niefield. University of Colorado Boulder
Kayla DesPortes and Yoav Bergner. New York University

We are investigating how teenage cheerleaders and step dancers, together with their coaches and trainers, can use computational technologies to assist training and performance. To do so, we are creating machine learning, data science, and wearables toolkits so they can capture data about how they move their bodies, and then use those data together with their coaches and trainers to create computational models of their movement. The dancers and athletes can use those models for real-time or post-hoc analysis to provide feedback during training, and to trigger dynamic light and sound in response to their movements during performances.

The practice we envision draws on disciplinary ideas from scientific modeling, statistics, computer science, and electrical engineering, and is situated within the institutional structures, social practices, and identities of dance and dancers. Consider the following example, which draws on the AlpacaML model building app we are creating:

> Carlie is a high school sophomore on the cheerleading team. She loves to dance and is thrilled to be able to bring her love of gymnastics to school. Right now, she is really struggling with her standing backflip. She understands what she is supposed to do- she must make sure she pulls both feet up at the right time. But in that moment where she's flying through the air, it always slips her mind. Carlie needs help attending to how she is moving. One of the seniors on the team, Mary, offers to help her to make a standing backflip wearable using AlpacaML. They velcro two sensor to her workout clothes- one to her ankle and the other to her shirt near the collar. The sensors' gyroscopes will let them record the angles she is positioning her body in, while the accelerometers will let them record how she moves her different body parts at each moment. They then use the AlpacaML app to record Carlie attempting ten standing backflips. The app captures video of her flips, and synchronizes the video recordings with gyroscope and accelerometer data so Carlie and Mary can see what Carlie was doing at each moment of data. Then they go to work, slicing up the video. They select clips where Carlie performed backflips correctly, and clips for times she did not, labeling them as they go. While they label, Mary gives Carlie feedback on what she sees in each of the clips, and why she thinks Carlie sometimes lands her flip, but sometimes touches out. Carlie needs to focus on her rotation by getting her toes up faster right after she reaches the highest point of her set and picking her chest up when she lands.
>
> Carlie and Mary then tell AlpacaML to train a machine learning model using the data that they recorded. They want the model to have three classes: "Great Job!", "Chest Up!", and "Faster Rotation!" Mary shows Carlie how to do some basic validation checking of the model using the 'Cross Validation' feature: they see that the system is about 90% accurate in labeling the video clips the same way Mary would. Good enough. Now it's on Carlie to practice, practice, practice, with help from AlpacaML. She puts her Bluetooth headphones in her ears, then tries a standing back flip again. "Great Job!", she hears. She does it again. "Chest Up!" It felt a little different than the first time, and the app could tell the difference. This time, she's going to really try to rotate fast and pick her chest up as soon as her feet hit the floor to see if that helps. It does. "Great Job!"

This conjectural vignette illustrates how we envision embedding computational modeling practices within dance training practice. In the vignette, Carlie and Mary identify a problem of dance practice, collect multimodal data, use those data to build a model of good and problematic movement that is suitable for giving advice to a dancer trying to improve a skill, validate the accuracy of the model, then apply the model in their dance practice. The design explicitly provides the dancers and cheerleaders with the opportunity to own their data in ways that go beyond just collection, which is the limit of most movement tracking devices. They also have control of sorting, labeling, model building, and appropriation of the data to fit their own practices, interests, and needs.

It is notable that machine learning is often discussed as an advanced computer science technique, and therefore not one that youth who are not computing experts would plausibly engage in (Joint Task Force on Computing Curricula, 2013). We contest this notion (Shapiro, Fiebrink, & Norvig, 2018) and, through this work, seek to discover "an intellectually honest form" (Bruner, 1978) of machine learning that is appropriate for embedding within cheerleading and step dancing practice.

Through doing so, we also seek to challenge the social construction of who is a cheerleader, who is a step dancer, and who is a programmer. Our culturally promulgated stereotypes of participation ascribe non-dominant gender and ethnic identities (women and Black, respectively) to cheerleading and step dancing, and the dominant identity of the white male to computer scientist. By developing machine learning and data science practices within the context of cheerleading and step dancing, we seek to challenge notions of who engages in the computational domains of machine learning and data science, while also intervening in the practices of dance training and performance to make them more computationally rich.

Data in motion: Bridging athletics and academics through physical computing

Marcelo Worsley, Stephanie Jones, Natalie Melo, Michael Smith, and JaCoya Thompson
Northwestern University

American culture is replete with the notion of "dumb jocks" and clumsy, or, unathletic nerds. Put in these terms, athletics and scholarship appear to be incompatible with one another. Furthermore, academics can be a barrier to participation when students do not maintain a certain grade point average. These are just two examples of how

social and institutional policies pit academics and athletics as being in competition with one another. The goal of Data in Motion (Perez, Jones, Thompson & Worsley, 2019) is to bridge this divide by helping students recognize and experience the bi-directional benefits conferred between sports and STEM. Concretely, Data in Motion, is a set of activities and technologies that push students to think about ways that wearables, sensors, and physical computing can help them improve their athletic performance. At the same time, Data in Motion incorporates experiences that situate core concepts from mathematics and engineering in athletic activities. In designing Data in Motion, we wanted to create experiences that would promote exploration, build on the utility of multimodal data, align with student interests and leverage the social and collaborative nature of sports. We achieve these through the use of existing and custom-designed wearables and software. These are coupled with thoughtfully curated activities that augment, or extend common sports drills with wearables.

In a recent week-long implementation of Data in Motion, with 2nd through 6th grade students, the research teams observed students experience dramatic shifts in their perception of the connection between sports and computing. Prior to the program most students saw little to no connection between sports and technology. Those who did articulated examples from mainstream televised athletics (VAR in soccer and augmenting the hockey puck for National Hockey League games). At the conclusion of the week, most students recognized that computing and technology could be used to improve their athletic performance. More importantly, the students had developed prototypes that explore a broad genre of technologies, and that were relevant to their particular sport of interest.

The design and development of this program, however, has surfaced a number of important considerations. For example, there is a need to identify and institute best practices for teaching students how to interact with complex, multimodal data. Additionally, there is a need to create low-cost software and hardware kits that will allow youth to more easily tinker with wearable, physical computing interfaces. Finally, we are examining how to implement this type of program within physical education classes and evaluating how it impacts student identity.

Importantly, the goal of Data in Motion is not to fill the often-referenced STEM pipeline. Instead, our goal is to help students realize new ways that STEM can connect to their lives and continue to value athletics as a legitimate learning space. While we do not lament the pursuit of traditional STEM careers, we want to empower students to recognize ways that their athletic prowess can support learning and innovation.

Summary

There appear to be several novel directions and opportunities for bridging sports, technology and learning. The papers described in this document reflect carefully developed experiences that are both theoretically and socially motivated. However, we posit that there remain a wealth of opportunities within this space, and are excited about engaging the broader learning sciences community in a discussion around existing challenges, ongoing opportunities and potential futures.

References

Bruner, J. (1978). The role of dialogue in language acquisition. *The child's conception of language*, 241-256.

Harper, S. R. (2006). *Black male students at public flagship universities in the US: Status, trends, and implications for policy and practice*. Joint Center for Political and Economic Studies, Health Policy Institute

Joint Task Force on Computing Curricula (2013). Computer Science Curricula 2013. Association for Computing Machinery (ACM) & IEEE Computer Society. Retrieved November 19, 2019 from https://www.acm.org/binaries/content/assets/education/cs2013_web_final.pdf

Perez, M., Jones, S., Thompson, J., & Worsley, M. (2019). Data in Motion: Supporting Youth Interest in Athletics Through Multimodal Data Analytics. *XRDS*, *25*(4), 50–53. https://doi.org/10.1145/3331073

Maybee, C., & Zilinski, L. (2015, November). Data informed learning: A next phase data literacy framework for higher education. In *Proceedings of the 78th ASIS&T Annual Meeting: Information Science with Impact: Research in and for the Community* (p. 108). American Society for Information Science.

Nasir, N. S. (2008). Everyday Pedagogy: Lessons from Basketball, Track, and Dominoes. *Phi Delta Kappan*, *89*(7), 529–532. https://doi.org/10.1177/003172170808900717

Nasir, N. S., & de Royston, M. M. (2013). Power, Identity, and Mathematical Practices Outside and Inside School. *Journal for Research in Mathematics Education*, *44*(1), 264–287. Retrieved from http://www.jstor.org/stable/10.5951/jresematheduc.44.1.0264

Nasir, N. S., & Hand, V. (2008). From the court to the classroom: Opportunities for engagement, learning, and identity in basketball and classroom mathematics. *Journal of the Learning Sciences*. https://doi.org/10.1080/10508400801986108

NCAA 2019. *NCAA Demographics Database*.

Prado, J. C., & Marzal, M. Á. (2013). Incorporating data literacy into information literacy programs: Core competencies and contents. *Libri*, *63*(2), 123-134.
Shapiro, R. B., Fiebrink, R., & Norvig, P. (2018). How machine learning impacts the undergraduate computing curriculum. *Communications of the ACM*, *61*(11), 27-29.
Shields, M. (2005). Information literacy, statistical literacy, data literacy. *IASSIST quarterly*, *28*(2-3), 6-6.
Watson, H. J. (2014). Tutorial: Big data analytics: Concepts, technologies, and applications. *Communications of the Association for Information Systems*, *34*(1), 65.