Personal Data and Team Dynamics: Tracking Technology in U.S. College Sports

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Abstract

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My dissertation focuses on coordination around personal data and human-data interaction in a high-stakes, high-performance environment: college sports. In the last decade, wearable tracking technologies—e.g., FitBit, Garmin, Catapult, Whoop, Ōura Ring—have introduced new data streams, such as heart rate and sleep measurement, which college sports teams hope to harness to improve performance, prevent injury, and gain a competitive advantage.

Sports teams, journalists, and entrepreneurs are all asking what *can be* done with tracking technologies? Their excitement about the potential of these technologies and the data they collect is shared by sports science and engineering researchers. However, when sports teams go to adopt these technologies, they face a myriad of options for tracking technologies and data management systems—all sold with the promise that tracking data could be used to keep athletes healthy by preventing injuries and overtraining and improve the team's overall performance to win more competitions. It is possible that none of the options available are what teams need, but the promise of tracking technology has lured the sports community nonetheless.

Drawing on socio-technical perspectives from Human-Computer Interaction (HCI), Computer Supported Cooperative Work (CSCW), Information Science and Discursive Design, my dissertation takes

a critical approach to the promise of tracking technologies. Instead of asking how tracking technology *can be* designed and used, I aim to shift the conversation to ask how tracking technologies *should be* designed and used*?* I examine how the adoption of tracking technologies may be disrupting current coordination between roles and explore how this disruption could make room for improved coordination and how the design and use of tracking data can support the needs of different roles at play in college athletics.

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Acknowledgements

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To all of November Project Seattle: thank you for always being there, welcoming me with open arms and being my source of joy and providing the social environment I craved in my early years in

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writing to giving me the resources I needed to succeed. And, thank you for supporting me through every possible challenging and exciting moment in life that I can think of for which I can never be grateful enough.

CHAPTER 1

Introduction

My dissertation focuses on collaboration around personal data and human-data interaction in a high-stakes, high-performance environment: college sports. In the last decade, wearable tracking technologies—e.g., FitBit, Garmin, Catapult, Whoop, Ōura Ring—have introduced new data streams, such as heart rate and sleep measurement, which college sports teams hope to harness to improve performance, prevent injury, and gain a competitive advantage.

Sports teams, journalists, and entrepreneurs are all asking *what can be done with tracking technologies?* Their excitement about the potential of these technologies and the data they collect is shared by sports science and biomechanics researchers who study and validate uses of tracking data (Bourdon et al., 2017; Cardinale & Varley, 2017) and engineering researchers who are enamored with developing novel technologies that have a narrow focus (e.g., Smart Soccer Shoe (Zhou et al., 2016)).

However, as sports teams go to adopt these technologies, they face a myriad of options for tracking technologies and data management systems—all sold with the promise that tracking data could be used to keep athletes healthy by preventing injuries and overtraining and improving the team's overall performance to win more competitions (see Figure 1 for examples). Realizing these promises is more difficult than it appears. Teams struggle to use tracking data to achieve their goals and are unsure if they can trust the technology or how it is being used (Kolovson et al., 2020; Luczak et al., 2020). Luczak et al., who interviewed 113 team strength and conditioning coaches and athletic trainers to understand how they currently use tracking technology, included this statement from a participant: "*Wearables are fool's gold*."

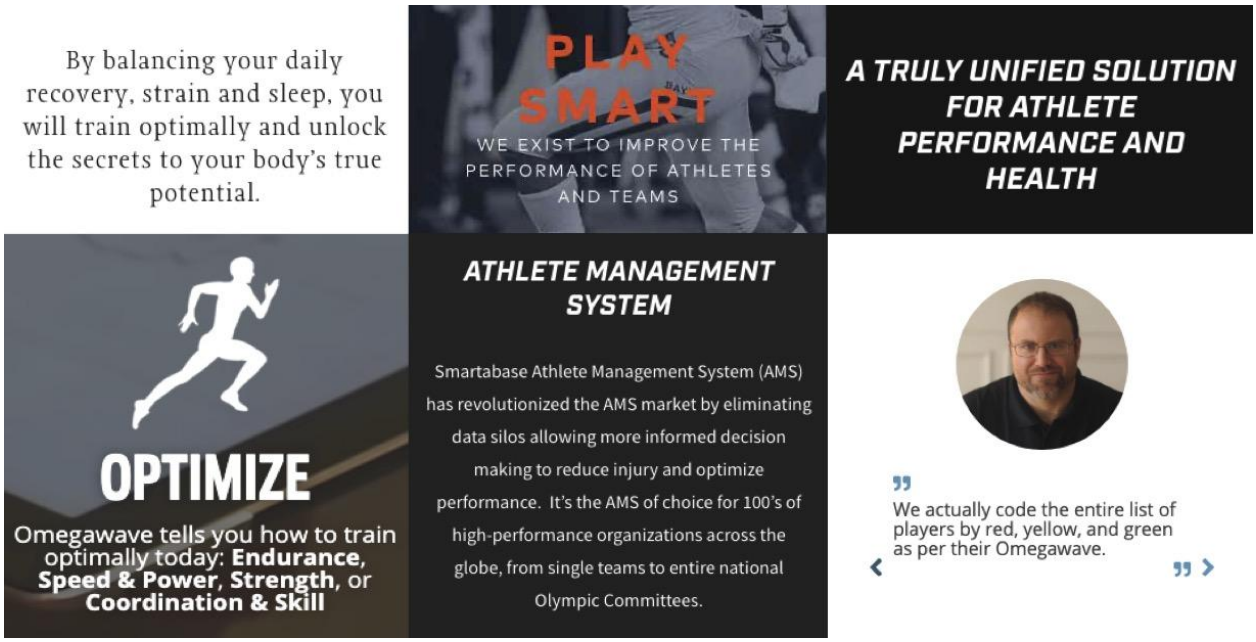

Figure 1. Examples of promises sports tracking technology companies use to sell their products. Clockwise from top left: Whoop, Catapult Sports, Fusion Sport Smartabase, Omegawave, Fusion Sport Smartabase, Omegawave.

I take a critical approach to the promises of tracking technology. Instead of asking how tracking technology *can be* designed and used, I aim to shift the conversation to ask how tracking technologies *should be* designed and used?

In taking this critical approach, I examine how the adoption of tracking technology may be disrupting current coordination on college sports teams. The disruption of current coordinations could lead to unintended consequences, but also opens the door for improving coordinations between roles on college sports teams. I also explore how designers and practitioners can support the use of and sharing of tracking data in a way that balances the needs of different roles on college sports teams and reflects the nuanced social dynamics at play in college athletics.

1.1. Dissertation Aims, Thesis, Structure, and Scope

In this dissertation, I will address two aims through nine chapters and will integrate two distinct but related studies. For a summary of these studies, their research questions and contributions see Table 1.

1.1.1. Dissertation Aims

Through two studies in this dissertation, I aim to address the following questions using different approaches:

1. *How do college sports teams currently coordinate around athlete personal tracking data?*
2. *How should tracking technologies be designed and used to balance the tensions between the goals and needs of different roles (e.g., student-athletes, coaches, and athletic trainers) around tracking data?*

In setting out these aims, I want to acknowledge that neither of these questions could be fully or definitively answered by this dissertation alone. For the first aim, I did not seek to understand how every college sports team is using and coordinating around athlete personal tracking data, rather, I sought to gain an in-depth understanding of how teams experience coordinating around tracking data from speaking with people across different universities, teams, and roles.

For the second aim, the word "should" denotes opening up opportunities for discussing what should happen rather than defining an authority on what should happen. There are many ways to answer this question of how tracking technologies should be designed and used. I am not the authority on what is best or what should be done, but rather I address this question with responses from my study participants about what they think should happen and by presenting heuristics that might structure further discussion about what designers and sports teams think should be done to balance the needs of different roles.

1.1.2. Dissertation Thesis Statement

In this dissertation, I propose the following thesis statement and set out to examine these claims:

College sports teams collect athlete information and coordinate around athlete data with and without tracking technology. Current data collection practices are extractive and studying coordination between team roles around athlete data reveals power dynamics between team roles and tensions between the needs of different team roles. Tracking technologies are disrupting current practices but the current design of tracking technologies is only reinforcing extractive data collection, power dynamics, and tensions in addition to threats to athlete privacy and agency.

However, the disruption of current practices by tracking technologies also presents an opportunity for change. Designers and users of sports tracking technology should consider how tracking technology could support data collection in ways that are not extractive, facilitate coordination between roles, address athletes needs for privacy and agency, augment human expertise, personalize insights, and facilitate decisions based on trends in data.

Furthermore, designers and users of sports tracking technology should also consider how to balance the goals of the team and the individual which presents many challenges to coordination and use of tracking data with and without technology. To promote design and use of tracking data that balances the goals of the team and individual roles, designers and practitioners can consider *customization*, *visibility*, *information flow*, and *legibility* in the design and use tracking technologies to support individual and team needs without compromising one of those needs.

Study and Research Questions	Contributions	Relation to Aims and Thesis
Personal Data and Power (Study 1) How are athlete personal tracking data currently used in coordinations between roles on college sports teams? How do athlete personal tracking data support team and individual goals and what tensions arise?	1. An ecology of collaborations, across four team roles, that highlight goals using student-athlete tracking data and sources of tension: power asymmetries, differing priorities, lack of access to or ability to interpret data, and reduction of agency. 2. Challenges for designers of systems that facilitate collaborations using personal data, such as the consideration of how the design of tools that collect data may reinforce or challenge power asymmetries. 3. A new type of boundary negotiating artifact, **extraction artifacts**, that highlight power asymmetries in collaborations.	Surfaces tensions between roles in college athletics around tracking data and discusses the power dynamics that these expose.
Speculating the Futures of Sports Technologies (Study 2a, Design) What are the college athletic community's *preferred futures* for the design and use of tracking technology?	How Research through Design can produce knowledge about the preferred design and use of sports tracking technologies in college athletics embedded in three video prototypes.	1. Further explores power dynamics, tensions around the use of tracking data, and moves from possible harms of adopting tracking technology to preferred futures for tracking technology. 2. Identifies preferred futures for how to balance the tensions between different roles around tracking data.
Speculating the Futures of Sports Technologies (Study 2b, Preferred Futures) What are the college athletic community's *preferred futures* for the design and use of tracking technology?	Preferred futures for the design and use of tracking technology in college sports: 1. The interpretation and use of tracking data: taking a holistic approach, using data to inform and not replace, focusing on individualization and trends. 2. The management of tracking data: how to support athlete agency and control when sharing data is not always optional. 3. Supporting athlete mental health given the pressure put on athletes and the affect data can have on athletes.	

Table 1. Summary of research questions, contributions and how each study relates to my dissertation aims and thesis.

1.1.3. Dissertation Structure

The structure of the nine chapters is as follows:

Chapter 1 introduces the motivation, approach, and structure of my dissertation. The first chapter also includes a statement of positionality relevant to my dissertation where I describe my experience as a student-athlete and the limitations of that experience and my perspective.

Chapter 2 describes the context of study for my dissertation: college sports in the United States. The intended audience for my dissertation includes both people who work in sports and researchers or designers who may not be familiar with college sports in the United States. It should not be necessary to be an expert on sports or U.S. college athletics to understand my dissertation, but the reader does need to understand why I chose college sports teams, the roles I discuss in my work, and the team and individual goals on a college team.

Chapter 3 motivates my work through a review of relevant literature. I also explain how I approach my research from a socio-technical perspective, drawing on the fields of Human-Computer Interaction (HCI), Computer Supported Cooperative Work (CSCW), and Information Science, which offer lenses into technology-mediated collaboration. My work also draws on Discursive Design which offers methods for prompting reflection about preferred futures. I introduce that literature in Chapter 5.

Chapter 4 describes Study 1 of my dissertation: Personal Data and Power Dynamics in U.S. Collegiate Sports (Kolovson et al., 2020). Study 1 applied the theory of *boundary negotiating artifacts* (Lee, 2007) to data from interviews with 11 student-athletes and 11 staff members (coaches, athletic trainers, and strength and conditioning coaches) describing use of and collaborations around

tracking data. Identifying these artifacts across four team roles highlighted sources of tension in these collaborations, such as power asymmetries, differing priorities, lack of athlete access to data, staff member's limited ability to interpret data, and reduction of student-athlete agency. Additionally, I proposed a new type of boundary negotiating artifact, extraction artifacts, which reflect my observations of how the staff members, working from their position of power in the collaboration, determine how athletes personal data are extracted without the athletes' input and in ways that the athletes cannot resist.

Chapter 5 describes the first part of Study 2 of my dissertation: Speculating the Future of Sports Technology. Study 2a uses discursive design methods to produce three videos designed to create discourse around preferred futures for the design and use of sports tracking technologies.

Chapter 6 describes the second part of Study 2 of my dissertation: Speculating the Future of Sports Technology. Study 2b describes the student-athletes, college staff, and designers' preferred futures for 1) Data interpretation and use of tracking data; 2) Management of tracking data, and 3) Supporting student-athlete mental health in relation to tracking data.

Chapter 7 draws together the findings from Study 1 and Study 2 to discuss how sports tracking technologies should be designed and used in college athletics and how to balance the needs of individual student-athletes and the team. I also present heuristics for navigating complex social dynamics and needs of student-athletes and the team in the design and use of sports tracking technologies. The heuristics are: *Customization*, *Visibility*, *Control*, and *Legibility*.

Chapter 8 concludes my dissertation with implications and future work and revisits the dissertation aims and thesis statement in closing remarks.

1.1.4. Dissertation Scope

The intended audience for this dissertation is researchers and designers in the field of Human Computer Interaction (HCI), designers of sports tracking technologies and other personal data technologies, and stakeholders of college athletics. I also position myself and many of the others who contributed to this work as researchers and designers whose goal is to understand the experience of teams tracking athlete data and determine how tracking technology can be designed and used to support the needs of different roles on a team and shared team goals.

In understanding the experience of tracking athlete data on teams, I relied on the experiences of student-athletes, coaches, and athletics staff collecting and using wearable data, rather than designing new data collection techniques myself. This approach supported the research goals by focusing on current and anticipated needs for and uses of tracking data, as well as what student-athletes, coaches, and staff imagine as a preferred future.

In examining existing and anticipated uses, student-athletes, coaches, and athletics staff often mentioned sleep data, as it is currently available from a range of devices and was previously collected through athlete self-report. Additionally because sleep data crosses boundaries between athletics and the rest of a student-athlete's life, it is also often illustrative of the privacy challenges associated with team use of data from wearables and other self-tracking tools. Consequently, sleep data is prominent in many of the examples in this dissertation. It is, however, just one example of the many data streams coming into use in collegiate athletics, including: heart rate, impact, blood oxygen level, location, nutrition, and motion-capture. I believe that the examples drawing on sleep can be illustrative of opportunities and tensions that will emerge from other data types. For example, impact data can be used to monitor athletes for concussions and protect them from life-long health problems caused by repeated head injury. However, many student-athletes choose not to report a concussion so they can continue participating in

their sport (S. C. Davies & Bird, 2015). If concussion history tracking becomes ubiquitous in sports, this could impact an athlete's career, resulting in not being recruited to be a college or professional athlete.

1.2. Positionality Statement

This section will discuss the strengths and limitations of my perspective and personal experience as a student-athlete.

1.2.1. My experience as a student-athlete

I was a student-athlete[1] at the University of Massachusetts Amherst immediately prior to beginning my work on this dissertation. As a member of the rowing team I experienced the social dynamics that I discuss in my dissertation, particularly the power dynamics on the team and between athletes and the coaches. Particularly as team captain in my junior year I struggled with the dynamics between myself, my teammates, and our coaches. Though we did not use any wearable tracking technologies as a team, some of my own experiences are reflected in the findings from Study 1 and Study 2. My team tracked speed/time for most workouts and there was a major conflict about recording data from our optional secondary workouts in a spreadsheet that the whole team and coaches could see. The tensions around this spreadsheet are similar to the tensions of agency versus surveillance described in Study 1. Also, the coaches' access to this spreadsheet and pressure to record this information that per NCAA rules the coaches were not allowed to collect, reflects findings from Study 2 about how optional is not always optional.

My experience as a student-athlete also made me familiar with the collaborations and data collection practices of the other roles I focus on in my studies: coaches, athletic trainers, and strength and conditioning coaches. And as a three-year member of the Student-Athlete Advisory Committee (SAAC), I

[1] See my team bio describing my rowing career at UMass.

pushed for the formation of an executive board to give athletes a stronger voice in the workings of the committee. Through SAAC and serving as the student-athlete representative to the Athletic Council[2] I came to understand even more about college athletics, different sports, and many other roles.

Though my experience as a student-athlete is most important to this dissertation, I feel that sports as a whole are nearly indistinguishable from my identity. My parents claim one of my first words was "touchdown" and I have been a hard-core Boston sports fan for longer than I can remember. Growing up I played soccer from age 5 to 14, did horseback riding from age 8 to 13, and in high school I was a 12-season athlete competing in rowing, swimming, and cross-country skiing.

My experiences as a student-athlete and my sports identity have both strengthened my work presented in this dissertation. From my own experience I am driven to ask the research questions that I do because I know that college athletics needs to be aware of the impact that tracking data could have on student-athletes if, in trying to improve performance and prevent injury, coaches or other staff members cause unforeseen harm. My experience and deep knowledge of college athletics also strengthens my work during data collection and analysis. I can ask questions of my research participants that someone else might not think to ask, I can empathize with and converse with the participants more effectively, and I can see connections between ideas and data where others may not. Additionally, I am able to bring together a multidisciplinary team of student-athletes and designers to conduct research with me. This helps ensure that decisions and analysis are not only influenced by my singular student-athlete perspective and the student-athlete perspective is kept in check by objective outsiders who do not have the same context knowledge.

[2] A council that met monthly or bi-monthly and included the Athletic Director, several Associate Athletic Directors in charge of finance, facilities, academics and other facets, several alumni, student government representatives, and a coach guest (this was always a different coach who gave a report on their team). At this council I was part of conversations that concerned budgets, facility plans, academics support services and other important issues for which the Athletic Director was responsible for making decisions.

1.2.2. Limitations of my experience as a student-athlete

Though my experience as a student-athlete is valuable to my work, there are several limitations of my perspective.

I am a white woman raised in a middle-class family in a well-educated community. I had the privilege of knowing I could attend college without an athletic scholarship and my decision to attend UMass was based on my desire to compete in rowing rather than a financial decision. When I started at UMass, I was not on an athletic scholarship, though I was able to earn one through hard work and was on partial or full scholarship from sophomore year onward. This is in contrast with many student-athletes who would not be able to afford university without their athletic scholarships.

Additionally, rowing has its own ugly history and culture. Historically rowing was a form of punishment, but in the last century up until recently rowing has been a upper class sport; boats are more expensive than an average new car[3] and running a rowing program has very little to no capital returns. The sport has thereby had a culture of exclusivity around it. The UW men's rowing team disrupted this in 1936 being sons of farmers and the opposite of the wealthy students who rowed at Harvard, Yale or other rowing powerhouse schools at the time (Brown, 2021)[4].

Rowing has one main claim of inclusivity and that was being at the forefront of gender equality in sports with the Yale women's team being a force in pushing for Title IX to be put into effect[5]. However,

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[3] Manufacturers do not always put their prices online, but I estimate the range to be $10,000 to $60,000 in US dollars with a new single person shell being around $10,000 US dollars and a new eight person shell about $60,000. A new car might be within this same range except a family only needs one or two cars whereas a rowing team has at least two or three eights, two to four fours, and maybe a few doubles, pairs, and singles.

[4] The University of Washington rowing teams are world-famous and before the US had a national team, collegiate teams would compete to represent the US in the Olympics. The New York Times bestseller *The Boys in the Boat* is the story of how the 1936 UW team beat out all the other college teams in the US to go to the Berlin Olympics where they won gold (Brown, 2021).

[5] In 1976, the Yale boathouse did not have a women's locker room. This meant that the women's team sat freezing on the bus after practice waiting for the men's team to shower before busing back to campus together. Captain Chris Ernst led her team in a protest where they marched into the athletic director's office with 'Title IX' written on their chests and backs, they took off their clothes and Chris read a statement that started with, "These are the bodies Yale is exploiting." Many of the women in the room that day went on to become the first women's Olympic rowers. Read the whole story here.

rowing is a very white sport and only until the last 5-10 years has there been a push for more diversity in the sport. Programs like Row New York have been instrumental in introducing rowing to teenagers that previously would not have had this opportunity.

My perspective is narrowed by my experience with a sport like rowing where most of my peers were also white and similarly privileged. My main exposure to students with other perspectives was as a part of SAAC where I worked with students in other sports. Though I have not always been successful, it has been my aim and on my mind wherever possible to assemble diverse perspectives on my research teams and recruit participants with different perspectives.

Additionally, as I discussed in the previous section, my experience as a student-athlete is a strength in my work but it is also a possible weakness. I am so close to the context of my work that it is possible for me to take something for granted or overlook something. An "insider's" point of view can be powerful but also blind to things that an "outsider" sees. Every researcher's interview skills improve with time, but mine needed to evolve to recognize when to ask an interviewee to explain something further for the benefit of backing up a finding for the research audience that I might take for granted.

1.3. The Research Team

Beyond my own positionality in my work, this dissertation was shaped by and is unique because of those I collaborated with. For every part of the work presented in this dissertation, I brought together multi-disciplinary research teams that included student-athletes and designers to work alongside me.

Due to rigorous training and competition schedules, student-athletes rarely get the opportunity to do research or explore academic endeavors outside of their majors. My research gave student-athletes the opportunity to work on a project that they are passionate about while learning how to do research. Working with students and especially having other student-athlete voices on the research team has been

the best part of my dissertation work. I have so much gratitude for the students who gave their time and energy to my projects.

I am also highlighting my research teams here because these collaborators contributed to and shaped the work I am presenting. The research team that contributed to my first study included student-athletes: Sam Goetz, Zoe Schaefer, Imani Apostol, Fred Huxam, and Brandon Maurice Lewis; and student-designers from my department of Human Centered Design and Engineering (HCDE): Natty Solomon, Erica Dillman, Ivy Kehoe, Ben Powell Wagner-Wilkins, Melody Yu, and Valerie Huang. This research team recruited student-athletes as interview participants, conducted interviews, and analyzed interviews that contributed to the results for Study 1. The perspectives of the student-athlete researchers and student-designers were key in interpreting and augmenting our understanding of the interview data, and in identifying challenges and opportunities with the design of sports tracking technologies. Additionally, Calvin Liang who, like myself, is a former student-athlete and an HCDE PhD student, contributed to the final analysis for this study that is presented in Chapter 4. Calvin's dual perspectives, alongside my own, contributed to the application of the Boundary Negotiating Artifacts theory (See Section 3.2.2), to the study data and contribution of *extraction artifacts.* For the specifics of what this research team contributed to, see Chapter 4, and for more information on this research team, see Appendix I.

The research team that contributed to Study 2a included student-athletes: Jenna Phillips, Clarie Marion, Lark Skov, and Brandon Wong; and students in various art and design majors: Ciana Yi, Dustin Mara, Nicki Chan, Chris Hong, Paul Fallon, Naomi Chau, and Drew Nevins. These students' contributions impacted the entire second study as they participated in the design and development of the videos featured in Study 2, which were subsequently used as probes for 15 interviews. Though the design of the videos built upon Study 1, the student-athlete researchers for this team brought new perspectives that were key in shaping the preferred futures represented and in the voices and interactions of the student-athletes and coaches in the videos. Likewise, the design students brought their video design skills

which contributed to imagining the future technologies that we were portraying. There was also some overlap in the students' perspectives as one of the student-athletes was also a design major and three of the design students were former student-athletes or had other relevant experience. These dual perspectives, like mine, contributed to the realism and success of the videos. For the specifics of what this research team contributed to, see Chapter 5, and for more on the research team and the design process, see Appendix II.

A third research team contributed to Study 2b and the results presented in Chapter 6. This team included: HCDE PhD student Sam So, HCDE Master's students Akshay Rawat and Nisha Jain, and HCDE Bachelor's student and volleyball player Roz Gille. Like the previous research teams, these students were selected to bring a blend of design and sport perspectives to the work. These students' contributions were in the design of the interview protocol, the recruitment of participants, and the analysis of the reactions to the three videos produced in Study 2a. This was a momentous task as these students were not only analyzing interview data, but had to figure out what these data contributed in response to the videos and the research question. These students further participated in discussions about what the findings contributed to the dissertation, resulting in the heuristics presented in Chapter 7. For the specifics of what this research team contributed to, see Chapter 6, and for a discussion that their work led to, see Chapter 7.

CHAPTER 2

U.S. College Sports

In this chapter, I will give an overview of my dissertation context—college sports in the United States—so that any reader not familiar with sports can understand the nuances of team dynamics. I will also include information about sports as a whole and decisions made about the focuses of my research.

2.1. Situating U.S. College Sports

Sports are played all around the world at all different levels and have a unique ability to unite different people and cultures as well as be a driving force of change. Another dissertation or several could be written about the organization of sports around the world, the culture that sports create, or a similar topic, so here I will focus on what is important to know about college sports in the United States and how it is distinct from other amateur sports organizations.

2.1.1. The National Collegiate Athletic Association (NCAA)

The National Collegiate Athletic Association (NCAA) is a nonprofit organization in the United States that regulates athletic competition for 490,000 *student-athletes* on 19,750 teams across 24 sports and generates nearly $1 billion in revenue (*NCAA.org - The Official Site of the NCAA*, 2022).

The term *student-athlete* was coined by the NCAA in order to designate college athletes as amateurs so the NCAA would not be obligated to pay college athletes (Watt & Moore, 2001). Recently, the NCAA has been forced by the United States government to allow athletes to make money from their name, image, and likeness, also known as NIL. A discussion of NIL is outside the scope of this dissertation.

To understand the research herein, the amateurism distinction is less important than a literal interpretation of the term *student-athlete*. The term *student-athlete* embodies the challenges NCAA athletes face: being a college student (e.g., courses, pursuing a degree, career exploration, and social events) and being a high performing athlete (e.g., training, traveling for competitions, competing, and staying healthy (Watt & Moore, 2001).

2.1.2. Why focus on the NCAA?

First and foremost, the choice of the NCAA as the context for this dissertation is my personal familiarity with the organization and inside knowledge of an NCAA athletic department. During my time as a student-athlete I interacted with student-athletes on 20 different teams and staff in different roles at every level of the department.

Second, what sets the NCAA apart as a useful context for study is that the NCAA provides a standard team and organizational structure across 24 sports and almost 20,000 teams (*NCAA.org - The Official Site of the NCAA*, 2022). This standard structure ensures that the same rules and regulations apply to all of these teams and the same organizational roles will exist on any of these teams, so I can conduct research that has implications about collaborations between different roles around tracking data *across sports*.

This model is distinct from both professional sports in the U.S. and the European model of sports organization. Professional sports in the U.S. are all organized independently by sport with an emphasis on profit and entertainment (*2022 Sports Industry Outlook*, 2022; Nafziger, 2008). Each of the different leagues such as the National Football League (NFL) and Major League Baseball (MLB) have different organizational structures and regulations. The European model also organizes sports independently, but has a model for organizing that creates more equality across levels of competition though a pyramid structure (Nafziger, 2008). The pyramid structure includes clubs at four different levels which allows

organization of competition at each level, facilitates the cultivation of talent, and distribution of revenue to promote improvement at all levels and strengthen the competition (Nafziger, 2008).

There are many more distinctions between sports in the United States and Europe, but most important to this dissertation is the NCAA's roles as an organizing body across sports. Though the European model might set up a similar structure across sports, the same organizing body is not responsible for multiple sports. This unique quality of the NCAA provides a space to study athletes who are considered to be at the same level across sports and are all subject to the same rules. Studying the design and use of tracking technology across sports is important because these biometric technologies are designed to access the human body rather than performance in a specific sport, so it is necessary to understand the perspectives on these technologies from folk participating in different sports.

Lastly, I focus on the NCAA because of *student-athletes.* Their competing commitments of being students and high-performance athletes as well as their social commitments as young college students complicates their motivations and goals. And, their status as amateurs who are compensated with scholarships and treated similar to employees but do not have rights or organized unions to defend their interests also leaves them undefended against potential abuses of tracking technology use. In the major U.S. professional sports leagues, like the National Basketball Association (NBA), there is a player's association that negotiates a collective bargaining agreement with the league to protect the player's interests (National Basketball Players Association, 2017). There is no such bargaining power for *student-athletes* in the NCAA.

2.2. Roles on College Athletic Teams

Drawing my contextual expertise and interviews with participants, I describe each of four roles within NCAA teams and the actions they take towards these goals. Throughout my dissertation I will often use the word *staff* to refer to the athletic trainer and strength and conditioning coach.

2.2.1. Student-Athlete (A)

A student-athlete (A) is an athlete who attends college while practicing and competing with a team (Watt & Moore, 2001). Teams differ by sport and athletes differ by position or individual strengths within that sport. For example, a student-athlete could be a goalkeeper on a soccer team or a pitcher on a baseball team. In general, the athlete's goal is to maximize and improve their individual performance while contributing as much as possible to the performance of the team. Although athletes are taught to value the success of the team over individual success, they are also in direct competition with their teammates for positions on the team (Jowett & Lavallee, 2007). In pursuit of both individual and team goals, athletes are often driven to participate as much as they can, even if they might injure themselves.

2.2.2. Coach (C)

Each team has at least one sport coach (C), who is the main decision-maker and leader of the team. Coaches are responsible for the team's performance and consistent losses would be blamed on the coach, so their main goals are maximizing and improving team performance. To be successful, they endeavor to enable their team to win by training their team to be as fit and skilled in their sport as possible (Potrac et al., 2013). Coaches often face a tension of prioritizing the team over individual athletes in their decisions (Wachsmuth et al., 2018).

2.2.3. Athletic Trainer (AT)

Athletic trainers (ATs) play a key role in a sports team as "facilitators of healthcare" (a phrase used by participants in Study 1), meaning they are responsible for the physical and mental well-being of the athletes on their team. This responsibility includes being the authority on decisions regarding the management of athlete injuries. Though they are not doctors, ATs have advanced professional training that allows them to treat acute injuries, rehabilitate previous injuries, and prevent future injuries. Their

main goals are effective injury prevention and rehabilitation to keep individual athletes healthy, which contributes to the team's success.

2.2.4. Strength and Conditioning Coach (SCC)

The role of strength and conditioning coaches (SCC) balances all four goals as they are responsible for helping athletes become as fit, strong, and resilient to injury as possible—e.g., through strength training (with weights) and conditioning (cardiovascular fitness activities such as running)—as well as coordinating modified strength training for injury rehabilitation with the AT. Though SCCs work closely with ATs, their roles are distinct—their day-to-day responsibilities are different and they undergo different levels of training. Additionally, with the influx of new tracking technologies, a person in this role is now often expected to use these tools to assess their athletes' overall ability to perform.

2.2.5.Other roles (not the focus of my work)

Student-athletes and teams in a university athletic department are supported by far more roles than the four I focus on in my work. I will give a brief overview of these other roles here[6].

For any serious injuries that an AT cannot treat, there is a team doctor who manages the athlete's care. Athletic departments also hire a number of academic advisors that support student-athletes with registering for classes, career planning, applying for scholarships, and, if a student is struggling academically, the advisor will help arrange tutoring (also supported by the athletic department) and help the student-athlete communicate with their professors.

An athletic department will also have an athletic director who oversees everything in the athletics department and many associate athletic directors who are responsible for certain areas like academics, facilities, finances, and specific sports that require additional oversight like football.

[6] For a full list, see the University of Washington Athletics Staff Directory as an example.

And lastly, there are alumni who support the athletic department as fans or with donations, and any other members of the community around the university or general public who are fans.

All of these roles are either direct or indirect stakeholders of tracking technology in college sports. I choose not to include these additional roles to narrow the scope and focus of my work to those closest to student-athletes and the use of tracking technologies. Including some or all of these roles in my work would add additional complexity to what is already a complex context to study. However, if I had expanded my scope, including athletic directors may have allowed me to comment on how university or NCAA policy should be changed to regulate tracking technology. Additionally, fans are a significant topic of conversation related to tracking technology in sports because tracking technology companies and the media hope to provide fans with further insight on their favorite athletes (Cohen, 2022a, 2022b; Cohen et al., 2022).

2.3. Goals on College Athletic Teams

There are four main goals on college teams that are in tension in my dissertation. These goals were identified through the analysis of interviews with participants from Study 1. Staff (AT, SCC, and C) discussed all four goals, while student-athletes only explicitly discussed maximizing and improving performance. Additionally, I use my own context knowledge to supplement the data from Study 1.

The overarching goal for any sports team is to **win competitions**: in particular, a final competition, usually called the championship. Winning is supported by four more specific goals that participants described focusing their efforts around:

1. **Maximizing performance** to win competitions. Individual athletes are concerned with performing their best on any given day and will employ recovery techniques such as ice baths or nutrition that will best fuel their immediate performance. However, this goal is also the coach's concern. The coach is responsible for fielding the best team possible to win competitions and/or

the championship. This goal is both the reason that a star athlete is competing in a championship game even though they are not fully healthy[7] and the reason that a star athlete might sit out mid-season to stay healthy for the championships[8].

2. **Improving performance** to win future competitions. This goal is a central focus for all the roles I study. Athletes train hard, practice skills or techniques needed for their sport, use recovery techniques, and/or eat well to become better at their sport which both improves their individual performance and the teams. Coaches manage their athletes' training and give athlete's feedback on their performance to push them to become better at their sport and help each athlete and the team reach their potential. Strength and Conditioning Coaches and Athletic Trainers focus on the next two goals which both support improving individual and team performance.
3. **Injury prevention** to keep athletes healthy for the sake of their own well-being and so they can contribute to the team's success. If athletes are injured, the performance of the team may suffer. Strength and conditioning coaches are mainly responsible for building up athletes' bodies to be stronger and more resistant to injury through weight training and conditioning. Though they cannot prevent acute injuries like broken bones due to impact, they can prepare athletes' bodies for the specific rigors of each sport so that overuse injuries do not occur. Athletes themselves are also concerned with staying healthy. They will listen to their bodies for signs of fatigue and take steps to recover properly (e.g., drinking water, stretching, ice baths, etc.). Coaches too aim to manage training so that athletes do not become injured.
4. **Injury rehabilitation** to return athletes to a healthy state so they can contribute to winning competitions. Athletic trainers are responsible for injury rehabilitation sometimes called return-to-play. They will treat athletes' injuries and work with the athlete, the coach, and the

[7] CBS Boston created a list of the Top 10 Gutsiest In-Game Performances by Injured Athletes. One example is the famous Michael Jordan flu game.
[8] For example, a CBS Sports article from 2015 describes how Golden State Warriors coach Steve Kerr used wearable technology data to decide to bench star player Stephen Curry to keep him healthy and to maximize his and the team's performance in the NBA Finals.

strength and conditioning coach to build the athlete back to full strength. This process can be delicate as the athlete could get re-injured, possibly more severely, if they do too much too soon.

Together, actions taken towards these goals are intended to give the team the best possible chance of success. However, within these goals there is a tension between the team and the individual. Individual athletes, with the help of staff members, are striving to perform well and stay healthy to improve their position within the team. Though each individual athlete and these staff members are also invested in these goals at a team level. In describing the goals above, I have emphasized which roles are more responsible for each goal because the tensions around tracking data surfaced in Study 1 show how each role (or even individual people) prioritize these goals differently. The priorities bring the team and individual into conflict and make it difficult to work towards one or more goals. These tensions may already be evident here, but should be kept in mind as the **team versus the individual** is a core tension needed to understand my work.

CHAPTER 3

Related Work

I approach my dissertation aims from a socio-technical perspective, drawing on the fields of Human-Computer Interaction (HCI), Computer Supported Cooperative Work (CSCW), and information science, which offer lenses into technology-mediated collaboration, power dynamics, surveillance, and agency. In this chapter I will motivate my dissertation aims using literature in these fields, specifically:

- What is known about interpersonal tracking in HCI and sports and why I study interpersonal tracking on college sports teams.
- What the *socio-technical gap* is and how CSCW can help me understand coordination and collaboration around tracking data.

3.1. Interpersonal Tracking

This section will provide an overview of interpersonal tracking research in HCI and sports, discuss what college sports teams can add to this research area, and motivate my first dissertation-level research aim, "*how should tracking data be collected and used on college sports teams?*"

3.1.1. Interpersonal Tracking in HCI and CSCW

Tracking in college sports is similar to other interpersonal tracking contexts studied in HCI and CSCW. Personal tracking data can be used to help patients work with health providers to diagnose and manage chronic conditions (e.g., (Chung et al., 2016, 2019; Schroeder et al., 2017, 2018)), to help families or social support circles work together to support an individual with a chronic condition (Murnane et al., 2018), and help families coordinate around their health (e.g., (Pina et al., 2017)).

These data-supported collaborations are unlikely to succeed without some alignment regarding the goals for the collaboration and if different roles cannot contribute their expertise to interpreting and acting on the data (Chung et al., 2016, 2019). College athletics teams have several clear goals (see Section 2.3) including one that is usually agreed upon—winning—and several distinct roles (see Section 2.2) with different expertise that are involved in data collection, use, and/or analysis.

In this way, college athletics offers an informative window into a phenomenon playing out in a range of settings: groups and organizations adopt personal tracking technologies to further some goal—productivity in the workplace, coordination among the family—but in doing so, reify or destabilize existing group dynamics, often with unintended and not yet well understood consequences.

3.1.2. Interpersonal Tracking in Sports

HCI research around sports has focused on designing novel technologies that support a specific sport (e.g., swimming (Kiss et al., 2019)) or a specific movement (Oakes et al., 2015)) and on facilitating social experiences around sport (Mauriello et al., 2014; Wozniak et al., 2017). HCI's examination of the social dimensions of sport technologies tends to see social features as a way to create accountability or motivation, such as through social fitness groups (e.g., (Lin et al., 2006)), games (e.g., (A. D. Miller et al., 2012)), or sharing (e.g., (Epstein et al., 2015)), leading to behavior change. Recent HCI research has studied the use of personal data and tracking tools by individual amateur and elite athletes (Rapp & Tirabeni, 2018; Tholander & Nylander, 2015). Some of this work touches on the importance of coaches in making sense of tracking data (Rapp & Tirabeni, 2018) or in the potential of data to support athlete-coach communication (Mageau & Vallerand, 2003), suggesting that the role of data in collaboration between athletes and coaches warrants further research. For example, professional soccer players described coaches as gatekeepers to the data: collecting, analyzing, and changing workouts based on the data all without the athletes ever seeing it (Rapp & Tirabeni, 2018). How do such uses support collaboration, and how do they alter the coach-athlete relationship?

Outside of HCI, research in sports psychology and sport science has recognized the importance of understanding the relationship among athletes, trainers, and coaches. Researchers have investigated dynamics across roles in sports teams, including the coach-athlete relationship (Jowett & Cockerill, 2002; Mageau & Vallerand, 2003; Olympiou et al., 2008; Wachsmuth et al., 2016, 2018), athlete pairs (Poczwardowski et al., 2019), and multidisciplinary collaboration among coaches and numerous support staff (e.g., team doctors, psychologists, physiotherapists, sports scientists) (Reid et al., 2004). Common themes show that these partnerships and collaborations can experience healthy and unhealthy conflicts, but are successful when there is shared vision, open communication, and compatibility (Jowett & Cockerill, 2002; Poczwardowski et al., 2019; Reid et al., 2004; Wachsmuth et al., 2018). Additionally, for the coach-athlete relationship, the coach is essential for managing conflict and creating an autonomy-supportive culture (Mageau & Vallerand, 2003), where the athletes have a more positive view of the coach-athlete relationship, which benefits athlete motivation (Mageau & Vallerand, 2003; Olympiou et al., 2008).

Another body of work outside of HCI is Anna Saw's work that centers on athlete self-report measures (ASRM). Research on the adoption and use of ASRM highlights the complexity of introducing new athlete data collection and interpretation tools into a team (A. Saw et al., 2017; A. E. Saw et al., 2015b, 2015c, 2016). ASRM can facilitate communication and sharing of information between athletes and staff and among staff. However, athlete concerns—about who would see the data they shared, how it would be used, and that they or their teams would be punished if they did not provide their data to the ASRM—point to power asymmetries between athletes and staff and concerns about staff surveillance of athletes in the collection and use of athlete personal data.

3.1.3. Awareness: Interpersonal Tracking Provides an Outside Perspective

By the end of this chapter, it would be reasonable to question why my dissertation focuses on supporting interpersonal tracking on college sports teams rather than studying how to design personal tracking for

college athletes so that they do not need a coach. It may even be reasonable to question if there is an argument for abandoning tracking technologies all together.

However, a key idea motivating my work is that tracking devices and coaches can, separately and together, provide athletes with an outside perspective. They can make athletes aware of things they cannot always perceive on their own such as their body movement, their behaviors, and their performance. Awareness is crucial because it can catalyze an important learning process: self-reflection (Baumer, 2015; Fleck & Fitzpatrick, 2010; Kocielnik et al., 2018; Turns et al., 2014). This is why professional athletes at the highest level, even those who compete individually, need a coach.

Hansen and Anderson argue that a coach's role is influencing an athlete's reflection—the way athletes perceive and organize experiences—is a key mechanism of learning (Hansen & Andersen, 2014). They introduce a theoretical perspective based on Goffman's Frame Analysis (Goffman, 1974) which is a method of studying how situations are defined through 'keyings' that allow someone to understand or interpret what is going on in a situation, image, use of language, or other interaction. There can be many different layers or laminations that introduce additional 'keyings' that influence how something is framed and therefore understood.

The coach's role, as Hansen and Anderson argue, is to stimulate athletes' reflection (and therefore learning) by framing their experiences in ways that increase motivation, commitment, and well-being. In other words, coaches make athletes aware of certain things that guide reflection and help athletes learn. Hansen and Anderson found that two frames that coaches in their study used were science and experience. The coaches made athletes aware of the science or experience behind aspects of coaching like developing a training plan and providing feedback about their technique or performance. The science and experience served as frames to support athletes learning and staying committed to the training plan.

So, athletes need coaches to provide them with external awareness, but why not design tracking technology to replace coaches? Or why must tracking on teams be interpersonal instead of athletes getting awareness from their coach and their tracking device separately?

I believe that no technology can or should replace a coach's ability to combine observation or insights from data analytics with expertise in their sport and a coach's ability to make strategy decisions like which plays to call in a game. However, the tracking technology can augment a coach's ability to provide awareness and make decisions about their athletes and the team. The following sections will further describe coaches' needs for having the tracking be interpersonal.

Additionally, it is true that myself or another researcher or designer could conduct work to support the design of tracking technologies for athletes' self-awareness and self-reflection. Existing technologies like Whoop or Oura Ring could help athletes become aware of their sleep behavior or other habits on their own. Athletes enrolled in both Study 1 and Study 2 described using tracking tools on their own. However, I believe along with many of the participants in Study 2 (See Section 6.3) that in a team context technology cannot or should not replace the coach and the value that a coach can provide as a human with experience, expertise, emotions, and the ability to adapt.

3.2. Coordination & Collaboration

This section will describe relevant CSCW literature on coordination, collaboration, and designing for the nuances of coordination and collaboration to motivate my second dissertation aim: "*How should designers and practitioners balance the tensions between the goals and needs of different roles (e.g., student-athletes, coaches, and athletic trainers) around tracking data?*"

3.2.1. Defining Coordination in College Sports

A core aim of Computer Supported Cooperative Work (CSCW) is: "*to understand the nature and requirements of cooperative work with the objective of designing computer-based technologies for cooperative work arrangements*" (Schmidt & Bannon, 1992).

My dissertation contributes to this core aim through showing that the use of tracking technologies and the data they collect are involved in the *coordination* between roles as boundary negotiating artifacts and through an understanding of how the design and use of these technologies can change to support *coordination* among roles.

What is *coordination*?

I define *coordination* based on work by Schmidt and Bannon (Schmidt & Bannon, 1992): *Coordination* is individuals in different roles knowingly working together towards a common goal or in different but interdependent goals. Furthermore, these people will coordinate because their work depends on the work of others in the same or different roles and so they are "required to cooperate in order to get the work done" (Schmidt & Bannon, 1992). However, being interdependent in their work does not mean that *coordination* is without conflict between individuals or different roles.

This definition fits a college sports team which is made up of many individuals in different roles who are working together, or *coordinating*, towards a common goal or towards different but interdependent goals. For example, all the individual athletes work together in training to improve their performance while the coaches and staff are working to help athletes perform better according to their role—sport specific skill training (coach), strength training (strength and conditioning coach), and injury rehabilitation (athletic trainer). All of these roles including the athletes must work together in order to be a successful team.

My dissertation focuses on the tensions that arise in the *coordination* between different roles around tracking data rather than the detailed processes involved in *coordination*. Through this focus, my dissertation will contribute ways that the design and use of tracking technology can better support *coordination* between roles.

Word choice: Why *coordination*?

I chose the word *coordination* because it has a neutral connotation. The words *collaboration* and *cooperative work* have a positive connotation to them which denotes that those involved in working together share an equal say in the goals they are working towards and are voluntarily participating (or at least compensated). As Schmidt and Bannon say, "...there is a connotation to the term 'cooperative' that assumes compliance, shared sentiments, etc." (Schmidt & Bannon, 1992).

In college athletics, coaches and other staff members hold a position of power over the student-athletes (See Section 4.4). Though the student-athletes may be voluntarily participating in their sport, they do not share an equal say and so describing coaches and student-athletes working together as *collaboration* feels uncomfortable. The word *collaboration* could be appropriate to describe the work between coaches and staff, but there are additional power hierarchies within the coaches and staff that similarly render this term uncomfortable.

3.2.2. Boundary Objects and Boundary Negotiating Artifacts

Star and Griesemer's boundary objects (Star & Griesemer, 1989) and Lee's *boundary negotiating artifacts* (Lee, 2007) both highlight the role of material artifacts in coordinating disparate perspectives in collaboration. Boundary objects are conceptualized as artifacts that easily cross boundaries by translating information across different viewpoints in a group collaborating towards some shared goal (though individuals may also have their own goals). Lee, however, pointed out that the concept of boundary objects depends on a standardized structure for collaboration and is too rigid to describe non-routine

collaborations and account for artifacts changing across contexts or transforming into new artifacts (Lee, 2007).

In response to these limits of boundary objects, Lee proposed boundary negotiating artifacts (Lee, 2007), in which her main postulate is that boundary artifacts are used to negotiate and push boundaries rather than the effortless translation ascribed to boundary objects. Lee's boundary negotiating artifacts are more fluid in their roles and may change according to context and use, and so they better describe artifacts used in non-routine or novel collaborations. This is especially true where, as Lee suggests, artifacts are used in sets of practices that are not always wholly agreed upon by the participants involved, which highlights the role of these artifacts in negotiating existing or new practices. Table 2 describes Lee's five types of boundary negotiating artifacts.

Previous research on interpersonal tracking in HCI and CSCW (see Section 3.1) shows the potential of using personal data to support collaborations intended to further individual health and well being (Chung et al., 2016, 2019; Kim et al., 2016, 2017; Schroeder et al., 2018). In particular, Chung et al. draw on boundary objects and *boundary negotiating artifacts* to examine and support patient-provider collaboration using patient-collected health data (Chung et al., 2016, 2019). Patients and providers create *boundary negotiating artifacts* in preparation for and as part of their interactions, but various breakdowns in communication occur due to limitations of these artifacts and of practices around their use (Chung et al., 2016).

Though Lee noted the value of *boundary negotiating artifacts* in describing non-routine and novel collaborations, the use of *boundary negotiating artifacts* in describing patient-provider collaborations shows that the concept can also apply to more structured collaborations. In these collaborations, much of the value of *boundary negotiating artifacts* comes from their ability to account for what happens when the structured collaborations have to encounter the messiness of everyday life. In college athletics—in which

teams have formal roles and routine activities—I find similar value in *boundary negotiating artifacts* to explain the movement and use of data between different contexts and roles.

Self-Explanation Artifact	Artifacts created by an individual for their own learning, organizing, recording, remembering, or reflecting. They can turn into another boundary-negotiating artifact when shared with others.
Inclusion Artifact	Artifacts created when self-explanation artifacts are shared with others and discussion around it reshapes it into a new idea and/or artifact. Inclusion artifacts facilitate discussion of new ideas.
Compilation Artifact	Artifacts created through the compilation and organization of information from different sources. These artifacts are used to pass crucial information, resolve conflict and bring the goals and understanding of two or more communities of practice into alignment.
Structuring Artifact	Artifacts created specifically to be used by other people to communicate a hierarchy, ordering, or direct or coordinate the activity of others. Whereas other artifacts can be more passive, these artifacts have an action component to them.
Borrowing Artifact	Artifacts taken from the original creator, augmented without the creator's input, and used in an unanticipated way. These artifacts are defined by the procurement of the artifact, not the creation, and, therefore, can be used as another type of artifact.

Table 2. Types of *boundary negotiating artifacts* (Lee, 2007).

Interpersonal tracking research (see Section 3.1) emphasizes the need to study dynamics between roles, collaborations around data, and how groups go about achieving a shared goal of supporting personal data tracking for an individual with a chronic condition. Chung et al.'s studies (Chung et al., 2016, 2019) focus on understanding and designing artifacts that sit at one boundary while Pina et al. (Pina et al., 2017) and Murnane et al. (Murnane et al., 2018) are focused on describing social structures and collaborative tracking practices.

In my research, I aim to bring together ideas from both lines of research, offering a deeper understanding of collaborative practices and artifacts at boundaries that exist within close proximity. Previous work noted the importance of aligning and communicating about goals (e.g., (Chung et al., 2016, 2019)) and resolving competing commitments (e.g., (Pina et al., 2017)) in these collaborations. My

dissertation work highlights tensions that arise in the use of personal data when people have different needs and goal priorities—both among and within individuals. Additionally, my dissertation contributes an extension to Lee's boundary negotiating artifacts theory (see Chapter 4) and a way forward to support tracking technology design and use that balances these tensions.

CHAPTER 4

Personal Data and Power Dynamics in U.S. College Sports (Study 1)

This chapter will discuss Study 1 published and presented in January 2020 at the ACM Conference for Supporting Group Work (GROUP) (Kolovson et al., 2020).

4.1. Introduction & Overview

To address the first aim of my dissertation—to understand how tracking data should be collected and used within college athletic teams—I delved into the college sports context through the following research questions:

- *How are personal data currently used in coordination between roles on college sports teams?*
- *How do personal data support team and individual goals and what tensions arise?*

I explored these questions using a qualitative approach where I conducted 22 semi-structured interviews that included student-athletes, coaches, athletic trainers, and strength and conditioning coaches from seven sports at three institutions in the United States. In my analysis, I use Lee's theory of *boundary negotiating artifacts* (Lee, 2007) as a lens, which provided organization to the otherwise non-routine coordination observed in my data and a language for discussing the nuances of the coordination between roles. Previous work examining the use of personal data in coordination and collaboration noted challenges with—and the importance of—goal alignment between roles in collaboration (Chung et al., 2016, 2019). My research further foregrounds issues related to differing goal priorities, including power asymmetries and privacy.

Through this study, I contribute:

- An ecology of coordinations around athlete personal data which are collected in a combination of different ways: through different sports tracking technologies, athlete self-report, and/or staff

observation. These data are collected and used to create different *boundary negotiating artifacts* (BNAs) (Lee, 2007). The coordination around these artifacts, across four distinct team roles, highlight goals for use of this data as well as sources of tension, such as power asymmetries, differing priorities, lack of access to or ability to interpret data, and reduction of student-athlete *agency*.

- Challenges for designers of systems that facilitate coordination using personal data, such as the consideration of how the design of tools that collect data may reinforce or disrupt power asymmetries.

- A new type of *boundary negotiating artifact*, *extraction artifacts*, that are created when data are taken directly from someone in one role by someone in another, who then creates an artifact that is used without any influence of the originator. These artifacts highlight power asymmetries in coordination.

Together, these contributions can inform designers seeking to better support coordination around personal data and boundary negotiating artifacts, specifically related to differing goal priorities, and issues of power asymmetry, surveillance, privacy and *agency*.

4.2. Methods

To understand how NCAA teams collect, collaborate around, and use data, I conducted 22 semi-structured interviews that focused on eliciting the perspectives of four different roles in an NCAA team. I interviewed 11 student-athletes (A) and 11 staff: three coaches (C), four strength and conditioning coaches (SCC), and four athletic trainers (AT). These roles, job titles, and responsibilities are consistent across the NCAA. Participants received no compensation for the study. Other than myself, the research team for this study included two former student-athletes and five current student-athletes at the time of the study. Like myself, these members of the research team drew on their domain expertise for the design of

the study, including recruiting and interview design. I also leveraged this domain expertise in the analysis and in presenting the findings, to include domain-specific context necessary for understanding the study findings and implications.

4.2.1. Recruitment

Being part of an NCAA team in any role usually means having little spare time because team practices and competitions, including travel for competitions, often dominate athlete and staff schedules. Therefore, individuals are unlikely to respond to calls for participation in research from unknown researchers, especially for a study not offering compensation (Caine, 2016). Due to these expected difficulties in recruiting from an already limited population, we recruited participants through the authors' personal and professional networks, student-athlete members of the research team reaching out to peers, and snowball sampling. In my recruitment, where possible, I sought participants from different sports and of various competitive levels, including Division I and Division III of the National Collegiate Athletic Association (NCAA), each with differing amounts of funding, resources, and recruiting available. Also, having prior knowledge of the different roles within an NCAA team, I specifically targeted recruitment towards the four roles I intended to study. The diversity in sport, institution, competition level, and role among participants allowed me to develop a more comprehensive view of the use of athlete data in NCAA teams.

Roles	**Gender Distribution**	**Sports Distribution**
Student-Athletes (A1-11)	7 female, 4 male	Cross country running, gymnastics, rowing, track and field
Strength and Conditioning Coaches (SCC1-4)	1 female, 3 male	Basketball, field hockey, lacrosse
Athletic Trainers (AT1-4)	1 female, 3 male	Basketball, ice hockey, rowing
Coaches (C1-3)	1 female, 2 male	Rowing, swimming

Table 3. Participant information for Study 1 by role.

4.2.2. Interviews with Student-Athletes

To understand student-athlete experiences with tracking data and how they are involved in or perceive the staff's coordination around their data, I oversaw my research team's (see Appendix I.B) conduct of 11 semi-structured interviews with student-athletes (A). Of these student-athlete participants, seven were female, four were male, three competed in gymnastics, six in rowing, and two in cross country/track and field. All competed for the same university. The interviews ranged from 33 to 47 minutes (mean: 39 minutes). These interviews were all conducted by two interviewers, both students—one student-athlete and one Human Centered Design & Engineering (HCDE) student. Each interview was audio recorded with the participant's consent. These interviews explored what athlete data are tracked, how these data are used, the effects of these data on the student-athlete experience, and their relationship with coaches and staff. Each interview started by exploring what information the athletes track themselves, what their coaches track, and how they or their coaches use these data. The focus then shifted to how data tracking, especially interactions with their coaches and staff about tracking data, affects their experiences as student athletes. The interviews finished with questions about how they feel about their information being shared among their teams, with their trainers, coaches, and with the public.

4.2.3. Interviews with Staff

To understand how staff collect, use, and collaborate around data, I conducted 11 semi-structured interviews with five athletic trainers (ATs), five strength and conditioning coaches (SCCs), and four coaches (Cs) representing three universities. Of these 11 participants, eight were male and three were female. They work most closely with athletes competing in basketball, rowing, swimming, and ice hockey. The interviews ranged from 33 to 100 minutes (mean: 48 minutes). Each interview was audio recorded with the participant's consent and conducted by the first author. In these interviews, I explored the goals and responsibilities of each staff member, their practices for data collection and use, and how they collaborate with other staff members and athletes. Each interview started by gaining an

understanding of each participant's job and how they collaborate with others staff members and athletes. My focus then shifted to the types of information participants collect about the athletes and how they use it. The interviews finished with specific questions about their experience with or perception of tracking technology and how this affects their jobs.

4.2.4. Analysis

The analysis for this study consisted of a multi-stage, inductive process that moved from memoing about emerging themes, through a collaborative sensemaking exercise with my research team[9] to develop an initial coding scheme, to a final stage of systematic coding and synthesis by Calvin Liang (a fellow HDCE PhD student) and myself. In each stage of the analysis, I leveraged the domain expertise of the student-athletes on the research team and experiences of Calvin, Kate Starbird (my co-advisor), and myself as student-athletes to strengthen our understanding of the data and create new understanding in our analysis. I likewise leveraged the perspectives of the non-student-athletes on the research team and Sean Munson (my co-advisor) to balance the student-athlete perspectives in analyzing the data.

In a first round of analysis, the research team began by memoing about recurring and emergent themes, further developing those themes during transcription and then meeting to discuss insights. When all interviews were finished and transcribed, we used a grounded approach informed by Charmaz (Charmaz, 2014) to identify salient themes inductively—through an affinity diagramming (Beyer & Holtzblatt, 1997) process that enable participation by a team of 11 researchers, including five current student-athletes (researchers, not study participants). Affinity diagramming took place in two phases, one for each group of interviews. Each affinity diagram was constructed over several sessions with the research team. These sessions were followed by extensive memoing to synthesize insights and connect themes within and across the different sets of interviews.

[9] Ten students in a Directed Research Group (DRG) in Fall 2017 and Winter 2018. Five of the students were student-athletes and five were HCDE students. See Appendix I.B for a full list.

In our first round of analysis, we identified coordination and tensions around data, its collection, and use as major themes. This prompted us to conduct a second, more focused, analysis to identify coordination and tensions around *boundary negotiating artifacts*. Calvin and I systematically coded the interviews, using a coding scheme derived from the first round and from *boundary negotiating artifacts*. This scheme included codes for identifying *boundary negotiating artifacts*, participant goals, coordinative and data-supported activities, and tensions in coordination, around data, and between individual and team priorities. We also conducted open coding, in parallel, to identify emergent themes.

After all the transcripts were coded, Calvin and I conducted a final round of analysis in which we organized our data around *boundary negotiating artifacts* we identified and used our codes to identify patterns in collaborative practices around these artifacts, how they are used, and the tensions that arise. Finally the research team met to synthesize this analysis into an ecology of roles, goals, and artifacts and to discuss themes that emerged across artifacts.

I present a combination of findings and discussion across three sections. Section 4.3 describes key artifacts created and used in coordination among the four roles described in Section 2.2. Section 4.4 describes power asymmetries around collection and use of data that highlight issues of agency, privacy, and surveillance. Section 4.5 describes tensions associated with differing or competing priorities between roles and how that affects use of the artifacts. Section 4.6 proposes an extension to the *boundary negotiating artifacts* theory, *extraction artifacts*.

4.3. Collaborations supported by Personal Data and BNAs

Looking at the data through the lens of *boundary negotiating artifacts*, I identified six different artifacts covering all five types of *boundary negotiating artifacts*. Each artifact mediates a coordination between two or three roles at a time. An artifact that mediates more than one micro-coordination may be more than

one type of boundary negotiating artifact and its type at a given time depends on the context and use. I describe the six artifacts we identified and the coordination around them in the following subsections.

4.3.1. Injury Report

The injury report, described by AT1, AT4, C3, SCC2, and SCC4, is a compilation artifact created by the AT. The AT compiles team and injury information and organizes it using tools such as Microsoft Excel, Google Sheets, or team management software (e.g., FrontRush). The injury report lists the team roster, the injury status of each athlete, and notes pertaining to the training limitations for each athlete (e.g., "no upper body" (SCC2)). The AT shares the injury report on a daily or weekly basis with the SCC and sport coach in whose context it transitions from compilation artifact to structuring artifact.

In the initial act of sharing the document, the AT passes crucial information to the other staff, and sharing initiates informal conversations between the AT and SCC and the AT and sport coach in which conflict is resolved and their goals and understanding are brought into alignment. Specifically, staff will negotiate what athletes can and cannot do in training sessions and come to an agreement (AT1, AT3, AT4, C3, SCC4). For example, C3 describes a conversation with an athletic trainer:

> *There is a back and forth and they asked me like, well this is the issue, this is the range of motion, these are the things that they can't do or they're in pain. Let's figure out what other ways that they can stay with the team and stay fit.*

Following these conversations, or when negotiation is not needed, the injury report is a *structuring artifact*: through this artifact, the AT directs the activities of SCCs and coaches, directing the modification of training for injured athletes. Thus, creating and sharing the injury report aligns with the AT's main goals of injury prevention and rehabilitation. As a *structuring artifact*, the injury report, like the athletic trainer, holds a unique place of authority for the decisions regarding an athlete's training while injured.

4.3.2. Wellness Data

Staff both formally and informally collect wellness data from athletes. This includes any non-performance information, such as sleep quality, fatigue, soreness, stress, and mood and can be collected through observation, self-report, and sleep tracking devices. The goals of collecting this information are to prevent injury and improve performance. Wellness is intertwined with performance so considering wellness data supports staff in effectively training their athlete and avoiding injuries (AT1, C2, SCC1).

Formal collection of these data happens through a daily wellness survey or questionnaire (A1, A2, A3, AT1, AT2, SCC1, SCC4). A2's team uses an app called TeamWorks to manage the survey; she and her teammates fill it out before practice each day. Some teams augment the self-report data with personal tracking devices, such as sleep trackers (SCC1, SCC4).

Informally, sport coaches, SCCs, and ATs also gather wellness data through observing athlete behavior and striking up conversations with athletes. Cultivating this relationship with their athletes helps staff to see irregularities (AT2, C2). AT1 and C2 both describe this informal gathering of information similarly as their way to keep a "pulse" on the team (AT1, C2).

The nature of the procurement of wellness data makes them a type of *borrowing artifact*. As Lee wrote on borrowing artifacts, "the concept of borrowed artifacts is focused on the procurement of an artifact and not its creation" (Lee, 2007). Whether collected formally through surveys or devices or informally through interactions, wellness data are borrowed, taken from the athletes with the athletes' knowledge. It is worth noting here that though the athletes may know these data are being collected, they may not have a choice about letting these personal data be extracted from them.

As borrowing artifacts, wellness data are augmented and used in unanticipated ways, sometimes as another type of artifact. Staff described augmenting wellness data with injury reports, objective measures, or both at once (see One-Sheeter).

SCC4 described creating an *inclusion artifact* where performance data are augmented with wellness data when he shared information about an athlete's personal life to explain an athlete's recent performance to the sport coach:

> *Anything that has to do with performance is under my umbrella and then me and the head coach sit down and we'll talk. 'I heard so and so broke up with his girlfriend, just a heads up, you know, he's been off lately.'*

As for how wellness data are used in an "unanticipated way," we define unanticipated from the perspective of the borrowee, in this case the athletes. Therefore, to know if athletes are able to anticipate the use, we need to examine uses of wellness data and how athletes think they are used. Also, in some examples, wellness data may appear, to the reader, to be used in an anticipated way, to achieve the staff's goals. However, Lee's example of a borrowing artifact is described as being used to "further the goals of the project". Therefore, the use of *borrowing artifacts* to further a goal qualifies as unanticipated in the lens of *boundary negotiating artifacts*.

In addition to the use described by SCC4, AT2 describes making a last-minute decision prior to training to protect an athlete's well-being based on wellness data:

> *Like if they look exhausted, you talk to them, they haven't slept, they haven't been eating, they've had an injury, then I find a way so they don't train.*

SCC2 also described how a sport coach uses reported soreness to inform training so that the athletes are not overworked:

> *[The coach] has in mind how each session should be: hard, medium, or light. After a hard day if the guys say their soreness or fatigue is low, then that means he didn't go hard enough and next time he can go harder. Now if it's supposed to be a light day and the next day the guys are sore then he knows he needs to back off.*

Despite having some knowledge of how all the other artifacts are used, only A1 was able to anticipate any of the use cases for wellness data. A1 describes an example similar to SCC2 (SCC2 does not coach A1):

> *I think it's just to gauge practice, so if everyone is consistently putting ones for soreness, they probably dial it back a little bit. I don't know if they would decrease our amount of practice if less people were getting sleep or feeling more stressed or something.*

A1 understands that the wellness data could affect practice, she anticipates a reduction in training intensity if the team is sore, stressed, or not getting enough sleep.

Neither A1 nor any of the other athletes anticipated any of the other uses, and if an athlete does not know how the data is used, any use could be unanticipated. A2, A3 and A6 all described not having access to their collected wellness data or knowing how staff members were using it. A3 specifically states:

> *No, we submit it, but we don't get to see the trends which is kind of unfortunate... So I don't know how [the coaches] use it.*

In this way, Lee's definition of *borrowing artifacts* characterizes wellness data and their use. However, as I will discuss in Section 4.6, there are also power dynamics involved in the creation of these artifacts that are not made salient by the current concept.

4.3.3. Performance Data

Though performance data have long been collected through observation in training and competition, participants discussed using a myriad of tracking devices to collect time, distance, pace, elevation change, GPS, calories, steps, acceleration, cadence, muscle activation, heart rate, and training load (training load refers to both internal measurements, the physiological and psychological stress of training, and external

measurements, such as duration, speed, and acceleration (Bourdon et al., 2017; Cardinale & Varley, 2017)).

Participants described experiences using seven different performance tracking devices. These experiences were mainly within the team context, where the team provided the devices and accompanying software (only A6 owned her own watch device). All seven are wearable devices: sensors worn on an athlete's body during training—e.g., a watch, chest strap, sensor built into a shoe, or a screen worn on an athlete's shirt. These wearable technologies mentioned are Polar[10], Catapult[11], Zephyr[12], Zebra[13], Athos[14], and FitBit[15]. These products monitor different values and differ in their intended uses, so some teams use more than one device. Polar, Zephyr, and FitBit monitor an athlete's physiological data such as heart rate, and Catapult and Zebra monitor an athlete's precise physical movement using accelerometers and gyroscopes. Athos differs from the others; it measures muscle activity using sensors in specialized clothing.

When athletes are tracked by any of these devices during training, the staff and sometimes the athlete can see real-time data (HR, muscles firing, other performance information). Watches, in particular, enable athletes to see real-time information at a glance. This contrasts with wellness data, which athletes are not able to see other than when they report it. However, in the case of Catapult, Zephyr, or other chest-worn devices, only the staff can see the data in real-time and they are shared with athletes only when staff choose to do so (I describe this briefly below and discuss it further in Section 4.5 and Section 4.6).

Data collected by these devices are reviewed and used in several contexts, corresponding to three different types of artifacts:

[10] Polar, https://www.polar.com/us-en.
[11] Catapult Sports, https://www.catapultsports.com/
[12] Zephyr, https://www.zephyranywhere.com/users/sports
[13] Zebra, https://www.zebra.com/us/en/solutions/intelligent-edge-solutions/rtls/sports-player-tracking.html
[14] Athos, https://shop.liveathos.com/
[15] FitBit, https://www.fitbit.com/

1. When an athlete reviews their own data in real-time or after the fact (described by A6, A7, and A9), the data are a *self-explanation artifact*. Only one athlete, A6, described owning her own device and could thus review her data at any time.
2. When a staff member collects these data, they are a *borrowing artifact*, as these data, similar to wellness data, are taken from the athletes. In this case, the borrowing is automatic and mediated by the device. These data are then transformed into other types of artifacts when staff organize and share data.
3. When a staff member organizes and reviews the data in real-time or after the fact, these data are a *self-explanation artifact* (AT1, AT2, SCC1, SCC4).
4. When an athlete and a staff member review the data together or staff members review the data together, the data are an *inclusion artifact* (see Trust versus Accountability). This designation is appropriate because the *self-explanation artifact* afforded by the device is reshaped into an *inclusion artifact* through discussion where new ideas or understanding is created. Participants also described *inclusion artifacts* from these discussions being incorporated into two *structuring artifacts*, the one-sheeter (see One-Sheeter) and the training plan (see Training Plan).

Participants cited all four goals in the use of these artifacts. For example, these artifacts can be reflected upon or used to identify trends or patterns that can be used to maximize and improve performance and manage injury rehabilitation (AT1, C2, SCC1), and, specifically, injuries can be prevented by using these artifacts to monitor training load (AT1, AT2).

4.3.4. Training Log

Athletes and their coaches both contribute to creating the training log, a *compilation artifact*. This training log is a *compilation artifact* created through the compilation and organization of information from several sources, including athletes, staff, and sometimes devices. It is used to pass important performance data

between athletes and staff and foster understanding between the roles. In contrast to the other artifacts, both athletes and staff can view the training log.

Each team selects their own format for the training log; for example, Google Drive (especially Google Sheets), Microsoft OneDrive, and TrainingPeaks were commonly used. On two teams, athletes were responsible for compiling, maintaining, organizing, and sharing the training log with their coach (A5, A6). Additionally, C3 explained that his athletes care about their data and correct him if he makes a mistake when adding their data to the log (C3).

Several participants described that by compiling the training log, they hoped to support reflecting on past performances and use trends to inform decisions about training sessions and competitions, ultimately improving performance (A6, A8, C2, C3, SCC2). For example, C3 describes using the times recorded from weekly tests—time trials where the swimmers are timed for a set distance—to get an indication of how training is going and if his plan is working:

> *[The tests are] assessing the effectiveness of the training program and our training cycles. So if I can tell if they're improving from test to test, then the training's doing what we wanted to do or if they improved from test one to two and then they might stay the same from two to three, that's okay. But if they're getting worse, that's an indication that they're being overtrained.*

C4 then uses this information to modify his training plan and learn from it to improve his plans in the future.

4.3.5. One-Sheeter

ATs and SCCs work together to filter information they gather from athletes and decide what to send to the coach. They do this because it is part of their role to inform the coach of matters where the coach may not

have knowledge or expertise or to which the coach is disinclined to pay attention (AT1). Additionally, the information must be filtered and simplified because the AT and SCC know that the coach has very little time to consider the information they provide, and that the coach can ignore or fail to absorb their information, especially if it is too complex—hence the one-sheeter:

> *[Me] and the athletic trainer can look and dive into the nitty gritty details. The coach needs it to be a one sheeter quick hitter... Really, really simple to understand. They don't need to know every minute detail of our data because to them it gets lost and it loses value. Can they go hard today or can they not?* (SCC4)

SCC4 and AT1 described other types of short and simple information as, for example, when speaking about an individual athlete's participation: "*yes, no, green, red*," "*they can play or they can't*," "*they can be in this drill*," and, when speaking about training intensity: "*back off, ramp it up, or we're doing good*."

Despite aiming to deliver a small amount of information to the coach, ATs and SCCs have to consider a lot of information themselves. They consider health data regarding an athlete's physical and mental well being, including injuries and information about their personal life. They also consider performance data regarding how much stress recent training and competition has put on an athlete's body. Plus, they have to consider this information for each individual and aggregate for the team, which AT1 describes as a "*huge challenge*."

ATs and SCCs draw on the other artifacts and any other information or expertise they have access to outside of these artifacts, to create a *structuring artifact*, the one-sheeter. This is where wellness and performance data as *borrowed artifacts* are transformed into *inclusion artifacts* when the AT and the SCC filter the important information and into a *structuring artifact* when they become part of the one-sheeter. As the one-sheeter may include simplified information from the other artifacts, it can be used to negotiate training (as it serves improving performance), injury prevention, and injury rehabilitation. Additionally,

the one-sheeter, supported by the AT and SCCs council, is a counterbalance to the coach's authority as it has the power to influence the coach's decisions

4.3.6. Training Plan

A common idea throughout the study data, across all roles, was that the data that teams collect is valuable because it informs decisions about training. In other words, the purpose of the five artifacts I have described so far—the injury report, wellness data, device data, the training log, and the one-sheeter—and the coordination around these artifacts is to make data-driven decisions about a sixth artifact, the training plan. Created by the coach to serve the overarching goal of winning, the training plan is a powerful artifact; creating the training plan is all about creating an effective plan that will result in maximized performance for competitions and improved performance over time so performance is maximized for future competitions.

The training plan is a *structuring artifact*: the sport coach creates and distributes it to athletes, ATs, and SCCs to direct and coordinate their actions. For example, the training plan structures when and what athletes will do for training, what decisions ATs make in regards to modifications to training for athletes who are rehabilitating from injury, and how SCCs structure their strength training. This distinguishes the training plan as a *structuring artifact* rather than a *compilation artifact* because it is directing the actions of others. However, the training plan is not a static artifact, it is in flux as it is affected by the other artifacts and collaborative work being done around them.

Sport coaches, ATs, and SCCs use the injury report to decide which athletes are able to participate in training and collaborate to determine specific limitations for each athlete and modify the training plan for injured athletes. Also, AT4 describes that the injury report results in modifying the training plan for the whole team if there is a common injury across multiple athletes. Additionally, staff use wellness data,

including observational data, the self-report survey, and sleep trackers, to modify the training plans for individuals or the team.

Similarly, staff described using performance information to modify (e.g., change training intensity, restrict training, or increase rest time) team training and individual training (AT1, AT2, C3, C4, SCC1, SCC2, SCC4). Both the device data and the training log represent information about past performance that can be used to make modifications to the training plan based on trends in team or individual performance, such as C4 described in Section 4.3.6: Training Plan. These trends can be from information collected daily or at strategic intervals (e.g., once a week, a month, a year). For example, AT1 and SCC1 use device data, specifically load, to know if the team is training too hard and may be at risk of overtraining and injury, which would necessitate modification to the training plan to include more rest in the current week:

> *What does the last week you just did look like compared to the previous four weeks? The acute week compared to the chronic week. And there's a range of a 0.8 to 1.3 that's a safe zone, anything above 1.5 puts you at 2 to 3 to 6 times the risk of injury for the next three to four weeks*. (AT1)

Here AT1 describes how he uses load, collected for every training session, to figure out when his team is safe and when they are at a greater risk of injury. Using this information he can "*tell the coach to back off or ramp it up or we're doing good*" so the coach can modify training accordingly.

4.4. Power Dynamics

Previous research on boundary objects (Star & Griesemer, 1989) and boundary negotiating artifacts (Lee, 2007) implies the role of power that either people or artifacts hold and how power dynamics affect collaborative efforts. Lee describes how two structuring artifacts were in conflict until one took precedence as the dominant structuring artifact (Lee, 2007). As one became more powerful than the other,

the creators of that artifact had more power in the coordination as their artifact structured the direction of the group's work moving forward.

Power is similarly implicit in the study data, and power dynamics are latent throughout. In describing the collaborative ecology of sports teams, a hierarchy of roles becomes clear. Athletes are often at the bottom of the hierarchy, despite being most directly involved in a team's success in competition. SCCs and ATs work with athletes to maintain and improve their health, but their role as intermediaries with the coaches gives them other avenues to assert power. Sport coaches (and especially head coaches) have the most influence over the team's actions, though their control may vary across context. For example, the coach may hold the most power and influence in team practice and competitions, but in a medical context, where the coach has little expertise, the AT's training and expertise can overrule the coach.

Power asymmetries across a team's hierarchy affect the creation and use of the boundary negotiating artifacts I identified. As in personal health data (Murnane et al., 2018), the data and artifacts evident in this study often mediate representations of the individual athletes to the staff and even to other athletes. My work shows how these data are not only presented by the individual—in this case the athlete—but how other roles, or layers in the hierarchy, also borrow or extract that information from individuals to support their work. Once collected, staff may share that information with other members of the team, as with the example of the training log.

Among the staff, where there is a less significant power asymmetry, coaches ultimately hold a lot of power because they control and have a final say in decisions about the team and training. SCCs and ATs use the one-sheeter to challenge the coach's power, but the coach can choose to follow their advice or not. They learn if their advice was heeded when the training plan is communicated to the staff; ATs and SCCs must then adjust their own plans for strength training and injury rehabilitation accordingly (AT3, SCC2). Staff describe rarely challenging a coach's decision. When they do, it is most often done by the

AT through the injury report. This power check illustrates the AT's unique role on the team as AT's are supposed to have unchallenged and "autonomous authority to make medical decisions in the sole interest of student athlete health and well being" (National Athletic Trainers' Association's Intercollegiate Council for Sports Medicine, 2019).

Though I did not specifically design the interview protocol around power dynamics, I found evidence for the role of power and its connection to artifacts across my results. The next two sections examine tensions across roles and artifacts, some of which emphasize who holds power and how power is embedded in a team's structure.

4.5. Tensions around Personal Tracking Data

Coordination around boundary negotiating artifacts in college sports teams are complex and nuanced. The coordination is generally cooperative in pursuit of the collective goals of improving and maximizing team performance and preventing injuries. However, tensions arise in which these team goals compete with individual goals, such as improving individual performance or rehabilitating an athlete's injury.

In this section, I describe the role of boundary negotiating artifacts in coordinating among differing priorities between staff members or between staff members and athletes. I also describe how the current artifacts support coordination and how they do not, leading to a discussion of opportunities for design around these artifacts and coordination. Though much of the coordination occurs without conflict, I present tensions surfaced by the use of self-reported and tracked data to discuss opportunities and considerations for the design and adoption of tracking tools.

4.5.1. Individual versus Team Goals

Staff find they can collaborate well when everyone's goals—injury prevention and improving performance—are aligned and when they have the necessary information to support good decision

making. For example, AT4 describes using the injury report to advocate for the whole team if they notice multiple injuries of the same type:

> *So if I have muscle injuries or a couple of guys are getting hip stuff or a couple of guys are getting shoulder stuff, you know tendinitis, things like that, that's the preventables, that's where I could say "hey, I think we're doing too much overhead" or "hey, we're doing too much single leg stuff we need to modify, we need to examine what we're doing in the weight room in order to make sure that we're not putting these guys [at risk of injury]."*

In this example, guided by his responsibility of preventing injuries, AT4 noticed a pattern of injuries in the data and advocated on the team's behalf to the SCC and sport coaches. Preventing injuries is the AT's priority, but it is a shared goal; prevention of injuries that could result from a problem with the training plan also supports the SCC and sport coaches' priorities of improving individual performance and maximizing team performance. Thus, when AT4 suggests changes to training that will protect the team from injury, the other staff generally value and act on such guidance.

In contrast, tensions can occur when the goal of supporting an athlete's rehabilitation competes with the goal of maximizing team performance in a specific event. AT3 describes push back from a coach after a reporting an athlete is not able to play due to injury:

> *That's a difficult part of this job, a lot of time you're conveying bad news... I'll get "he's soft" or "he can play through that" and I'm like alright but he's not going to play. I think some of that is just frustration that they have somebody out because obviously every coach wants every athlete to be at 100 percent at all times. They expect that and it's just not going to happen.*

In the situations that AT3 described, the coach was upset and pushed back because this athlete was part of the coach's plan to maximize team performance in an upcoming competition. When an athlete cannot play, this can jeopardize team performance. While playing an injured athlete for the benefit of the team may seem irresponsible, it is a tension for coaches and for athletes themselves: many athletes want to play to maximize short term success, even if it comes with risk of injury or slower recovery. Legendary sports stories—Michael Jordan playing with the flu so the Chicago Bulls could move on to win the NBA Finals or Jack Youngblood playing with a broken leg through the NFL playoffs—show that the risk may be worth the reward if it would help the team win a playoff or a championship competition (Boston, 2016).

Within the NCAA, teams are required to follow a model of medical care in which the AT prioritizes individual athlete health and safety over other priorities and has authority over medical decisions. However, in a recent survey of NCAA ATs, half of the respondents reported not following the NCAA model of care. Additionally, a sixth reported experiencing pressure to "make a decision that was not in the best interest of a student-athlete's health" (National Athletic Trainers' Association's Intercollegiate Council for Sports Medicine, 2019). Based on the study data, some of this tension results from the inherent uncertainty of decision-making, and that an individual's priorities may cause them to read that uncertainty differently.

Though all roles hoped that data from self-report and devices can better inform the decision to rest or play an athlete, the data and the coach's and staff's current knowledge of how to interpret them rarely provide certainty. However, participants in this study reported some situations in which personal data and the boundary negotiating artifacts created from them, prompted an AT to take action and helped provide support for the AT's decision to protect a student-athlete's health. In the example from Section 4.3.2: Wellness Data, AT2 was motivated to "find a way" to make sure an athlete does not train if wellness data indicate that an athlete needs to take a break and rest.

Similarly, device data can help an AT feel more confident in their injury rehabilitation decisions. AT1 and SCC1, who work with the same men's basketball team, described using device data to give the coach an exact quantification of how much an athlete should train while recovering from injury:

> *We had a guy this year, we used [the device data] a lot for return-to-play because we had baseline numbers of things he did before he got hurt and once he came back... we literally had it down to the steps, the amount of jumps, to the load, it was really helpful*. (SCC1)

> *So if I knew he was going to go 3000 steps today, next week I know he was going to do 3300 and on and on...we could say to coach at practice, he's 50 percent of the way there, he's 75 percent of the way there, he's 90 percent of the way there...for a long time it used to be well, he's got 45 minutes. Well is that 45 minutes all together? Is that 45 minutes over the course of the two hours?... As long as we have baseline data upfront then we can more precisely manage and not guess.* (AT1)

This more precise data and communication—the creation of guidance as a structuring artifact—gave AT1 confidence in his decisions and that the coach and athlete would follow them in training.

4.5.2. Trust versus Accountability

A good relationship between athletes and staff, earmarked by trust and effective communication, is important for success, including both individual and team athletic performance and individual well being (Jowett & Cockerill, 2002).

At first, staff goals of using device and self-report data to maximize performance and prevent and rehabilitate injury seem well-aligned with athlete goals of performing well and staying healthy. However, performance and staying healthy are only a subset of a student athlete's priorities; a more complete understanding surfaces potential tensions.

For example, similar to tensions between coaches and ATs, athletes who are injured may want to play through their injury (Karkazis & Fishman, 2017; Madrigal et al., 2015), putting athletes into conflict with the AT whose job it is to protect athlete well-being, even from themselves. Athletes have many reasons for prioritizing competing over their own well-being, such as love of the sport, desire to be on the field, helping the team, sacrificing themselves to win a game, and that playing through injury is an accepted behavior (Karkazis & Fishman, 2017; Madrigal et al., 2015).

A11 described a time when he disregarded early signs of injury. His coach and AT picked up these signs through observation (back pain) and from device data (elevated heart rate or a high training load). His coach and AT wanted him to sit out, but A11 convinced them to let him continue training and competing:

> *They were telling me because of my back that I should stop, or take time off, but I felt like it's not as bad as they think it is or whatever. I don't remember exactly what I told them, but basically I just convinced them to let me keep going.*

He eventually sustained a serious back injury, was seen by a doctor, and had to take time off. Scenarios like these frustrate AT4, who described many athletes coming to him complaining of chronic pain or an injury that has existed—and worsened—for months before the athlete decides to seek help. Literature even describes athletes asking ATs or doctors to lie or keep an injury a secret so that they can keep competing (Reid et al., 2004).

Athletes also spoke of the opposite scenario: feeling fatigued or in need of a break, but being unable to convey the seriousness to their coaches. A1 noted "*the only time we get sent home is if we're throwing up sick*," i.e., when there is a visible and disruptive problem. A1 wanted to protect herself and prioritize her health, while her coach strives to keep her training consistent. However, if an athlete's self-assessment is not taken seriously in deciding what to do, the more visible evidence may be too late to

prevent more serious injury. A2, a teammate of A1, believes that device data could support how she is feeling and help her communicate to her coach in a way that provides evidence for action:

> *You know when you're fatigued and you know when you're feeling good and I think wearable technology can help reinforce that and it can also help with the coaches because the coaches don't know, they can't read your body completely. And so if that matches how you're feeling, it might be easier to communicate and for them to believe you.*

A5 similarly wanted his coach to know when he was putting in effort and which of his teammates were not; A5 believed that heart rate data could provide better insight into this than coaches' observation alone.

AT1 and SCC1's use of data to quantify training (Individual versus Team Goals) suggests that device data may offer such insights. However, none of the athletes in this study discussed successfully using data in this way, perhaps because they did not have access to the data or the expertise to interpret it as AT1 and SCC1 did.

Where staff and athlete priorities aligned around improving performance, staff found device data useful for facilitating teaching moments with athletes. For example, AT1 describes using performance data as an inclusion artifact to help athletes better understand their limits and levels of effort:

> *We can show an athlete that when they feel like they've given everything and it looks like they've got more to give or yes they really have given max effort, we can show them what it feels like.*

Through reviewing this data together, AT1 works to help athletes learn the actual effort that corresponds to their perceived effort, so that they can more reliably train at the level directed by the coach or training plan.

4.5.3. Limited Time versus Data Interpretation and Sharing

Time constraints, and ability to interpret data limits coordination between athletes and staff. Previous research notes that athletes may misinterpret wellness and performance data, drawing errant conclusions, if not supported by professionals (A. Saw et al., 2017). However, staff in this study also noted that they may not have the expertise to analyze all of the self-report and device data they collect, and they can find themselves overwhelmed (AT1, AT2, SCC1): "*We have so much information we could be doing so much more with... People who are doing this the most have [their own] staff*" (SCC1). This suggests a need for both additional training and resources to fully understand and use the data.

The training log offers one example of the athletes being able to put in the time, even if the staff cannot. Though athletes spend time adding their data to the training log or curating it, their coach may not add the data they collect to the log, show they have seen it, or reliably use the data to adjust their plan. A6's coach requires her team to add comments to their data in TrainingPeaks to get athletes to reflect on their performance, but A6 is frustrated that her coaches rarely respond: "*[The coaches] get an email every time we update or write anything inside the log but they rarely view the emails or respond. Unless you're really special.*" Though this may be due to coaches' time constraints, athletes perceive the limited replies as disinterest or favoritism.

In the case of the wellness surveys, staff collect the data, but athletes do not see that data again once they send it: "*We submit it, but we don't get to see the trends which is kind of unfortunate...*" (A3). As a result, athletes do not have the opportunity to reflect on and analyze their own data or to use that data to initiate conversations with staff about how they are performing or responding to training. The responsibility for interpreting the data and initiating conversations is left to staff.

Athletes also have limited access to data collected using team devices. Among the study participants, all team devices transmit data directly to a team dashboard, where the staff can view it; they do not have interfaces for athletes to view the collected data. Consequently, when athletes wear a team

device, the staff are gatekeepers of these data and athletes are only able to see it when staff share (AT1, SCC4). Sometimes athletes do ask to see the data, starting a conversation. A10 describes asking to review the data and the limits of that review:

> *If I want to go see the data I could go talk to one of my coaches and say like 'Hey can I see my past 3 workouts?' and they'd be like here, yeah. And take a look at it with me. But I don't have my personal data at home.*

When staff are the gatekeepers to both device and self-report data, this puts the job of understanding and acting on data on the staff rather than framing interpretation and action as a shared priority of both athletes and staff. This is unfortunate, because—as shown in the previous section, Trust versus Accountability—sharing data with athletes can result in a better shared understanding between staff and athletes.

In contrast to data collected by teams, athletes who have their own devices can review the data at any time. These athletes describe how seeing their own data and reflecting on it can help them understand their performance and training:

> *It's nice to look back later and you can track your run on a map where you can look at elevation gain and loss and how your cadence changed.* (A6)

> *[The device data] gave me a better sense of what I was actually doing... why I felt so exhausted and why I felt good from day-to-day.* (A8)

Given the positive experiences athletes can have with their own data, there is lost potential when athletes do not have the opportunity to review data that the staff collect, either on their own or with staff. Overcoming barriers to coordination could create more opportunities for staff and athletes to collaborate productively.

4.5.4. Agency versus Surveillance

To help manage and navigate competing priorities, athletes have often been selective about what personal data they disclose to staff and how. Tracking changes athletes' ability to manage what they share and how they present themselves.

Staff want ample and accurate wellness information, as it helps them train their athletes and avoid injuries (AT1, AT2, C2). Athletes also value wellness information because it is intertwined with performance (A3, A8, A11), and they know that providing their staff with this information can help them better understand their performance.

Though tracking can provide information that informs decisions and can result in benefits, the automatic collecting and sharing of athlete data also diminishes an athlete's ability to control what they share and how they present themselves. For example, athletes worry that information could affect their status on the team, if and how hard they train on a given day, and whether they compete. Wellness data that reveals violations of team rules or expectations—e.g., not getting enough rest—can also result in punitive actions for individuals or the team.

Experiences with sensed sleep data highlight some of these trade offs of tracking. Athletes have many reasons for not getting enough sleep, such as schoolwork, difficulty adjusting from travel, or wanting to spend time with friends. However, being short on sleep can both affect performance and increase risk of injury. If an AT or coach believed that an athlete was at risk for injury due to lack of sleep they may keep that athlete from practicing or competing.

In practice, however, athletes routinely do not self-report the most precise or accurate information about their sleep. To do so would mean that going to a party with friends or staying up late finishing a course paper would risk their standing on the team. From solely a safety and performance perspective, accurate self-report or pervasive, objective monitoring of sleep may appear desirable. Student-athletes,

however, have many priorities beyond performance. A3 describes how she and her teammates distort their sleep on the wellness survey to maintain their status on the team while participating in the other parts of their lives:

> *A lot of us don't truly, honestly, fill it out properly. Like if we don't get enough sleep, we're not going to be like, "oh I got three hours of sleep" because if we have a shitty practice they're going to be like "you should have slept more" and I'm like well…*

Across many conversations and ways of reporting data, athletes similarly carefully manage the information they disclose. This is easiest in conversations and self-report instruments, where they have the most ability to shape what they share. Sometimes athletes distort or selectively share information to avoid specific negative consequences (e.g., being kept from competing), while other times these distortions have a more general goal of saving-face or impression management, recalling the idea of a "Front" from Goffman (Goffman, 1959). Athletes noted that the increased use of tracking data makes it harder to shape what they share.

Sometimes data leads to disclosures athletes do not desire but that are ultimately beneficial. A8 described a time when their coach noticed a difference in their performance, which led to a discussion and the athlete revealing that they had been taking antidepressants. She did not initially reveal this to her coach because she did not want this to negatively affect her coach's decisions about her position on the team, but, once disclosed, it helped them reach a beneficial, mutual understanding of her performance.

Staff described awareness of possible distortion of data from various sources, particularly sleep (AT1, AT2, SCC1), though SCC1 indicates that he is confident in the data when athletes report 4-6 hours of sleep. Some staff also believe athletes deceive their tracking devices so it appears they are sleeping—e.g., by remaining completely still while watching a movie (SCC1) or by handing the tracker off to another person who is going to bed (SCC4). SCC4 assumes this to be the case when he observes signs of partying or a lack of sleep—e.g., alcohol on the breath, apparent fatigue—that are inconsistent

with the sleep data reported by the device. In this way and by considering athletes' personal lives and personalities, staff sometimes surmise—accurately or inaccurately—that athletes are distorting their data (A. E. Saw et al., 2015b).

Both athlete distortion of data and staff knowledge of this practice is consistent with prior work on athlete self-report measures (A. E. Saw et al., 2015b). However, as staff rely on their instinct rather than evidence of distortion, there can be no certainty of accuracy for athlete self-reports. Without a different approach, the value of such reports is diminished (A. E. Saw et al., 2015b, 2015c).

On the other hand, staff may put too much confidence in tracked data. While SCC1 and SCC4 described ways in which they are skeptical of tracked data, other staff may believe that just because data came from a sensor, they are accurate and reliable. This could result in over-training a fatigued athlete. Athletes also believe that staff sometimes use tracking data to make inferences that they do not actually support. This, in turn, can cause the athletes to focus on optimizing the data rather than the outcome. A8 describes how knowing her coach makes decisions based on heart rate data causes her to sometimes prioritize heart rate over rowing well:

> *Sometimes I wish the coach didn't know my heart rate because they will call you out...I would appreciate having the trust that I'm going to work my hardest to be in the necessary work zone without having somebody breathing down my neck because I guarantee you that I start to row crappy and my technique gets worse because I'm trying to get my heart rate up.*

While power asymmetries have always existed in high performance sports teams, tools that extend further into athletes' daily lives and that use automated tracking—even when intended to support both individual and team priorities—can magnify these asymmetries and disrupt teams' existing ways of managing them.

4.5.5. Discussion: Designing to addressing tensions around differing priorities and overcome barriers in collaborations using personal data

Throughout their collaborations, staff and athletes use personal data and boundary negotiating artifacts that include these data to inform decisions, coordinate actions, and balance priorities. In collaborations between staff, conversations around these data and artifacts can help align priorities, leading to agreement about plans for individual and team training. In collaborations between staff and athletes, conversations around performance data can lead to shared understanding, leading to improved performance. Additionally, our findings describe challenges and opportunities for further facilitating these collaborations by supporting boundary negotiating artifacts in design.

In Section 3.1.1, I introduced research on the use of personal data to support collaborations that further individual health and well-being. The previous research identified a lack of communication about goals—and resulting misalignments between goals—as a key barrier to successful collaboration (Chung et al., 2016; Schroeder et al., 2018). Our findings in sections 4.1 and 4.2.1 similarly describe tensions when goal priorities are not aligned. However, our findings also describe successful collaborations where the goal priorities are aligned and ways personal data can support coordination and alignment of priorities. For example, personal data can reduce uncertainty in decision-making for ATs, which helps them collaborate more effectively with the coach.

Previously, researchers have proposed designs that help patients articulate their goals, so providers can tailor tracking and management plans to those goals (Chung et al., 2019). Here we suggest some ways researchers and designers might facilitate successful collaboration around personal data on teams.

Section 4.5.3 describes how data overload, lack of time, and lack of resources for analysis are barriers to collaborations between athletes and staff around personal data. Overcoming these barriers could create more opportunities for staff and athletes to collaborate productively. For example, if staff are

able to harness and analyze the data they have more swiftly into *self-explanation artifacts* for their own understanding, they would be able to use it to further their goals and have more time to discuss the implications of the data with athletes. Additionally, finding ways to support the review of data asynchronously, making it easier to share the data (e.g., importing it directly to the training log) could create more *inclusion artifacts* that could bring together the athlete and staff perspectives. Also, if staff could easily create *inclusion artifacts* based on the data to provide feedback to all their athletes, then all athletes could benefit from the data collection and the staff could have even more time for discussions with athletes. Finally, when staff are not able to analyze the data, returning it to athletes for their own reflection and analysis, with appropriate scaffolding, could create new opportunities for *self-explanation*.

However, we also find situations when goal alignment may not be possible. For example, both staff and athletes face dilemmas about whether a star athlete should play or sit out a key competition when they are at a heightened risk of injury. In such cases, researchers, designers and practitioners should instead consider how to support the team or the individual actors in coming to a decision that not everyone will agree on. For example, an *inclusion artifact* that uses the athlete's data and predictions for the teams performance to bring together the staff and the athlete to weigh the risks of the athletes participation against the benefits to the team. Or, similarly, a *self-explanation artifact* that supports the athlete in weighing their options on their own.

As personal data are increasingly used in collaborations, researchers and practitioners need to continue to develop new guidelines and design patterns that help individuals and groups make effective use of these data and artifacts that include them. For example, we might emphasize the creation of *inclusion artifacts* that help bring together and balance multiple perspectives.

4.6. Extraction Artifacts

Tracking breaks down routines and shows how extraction represents an important type of coordination artifact.

4.6.1. Tracking breaks down existing team routines, threatening athlete agency

Nelson and Winter introduce the concept of routine as truce within organizations: to manage individuals' competing goals, "routine operation is consistent with routinely occurring laxity, slippage, rule-breaking, defiance, and even sabotage" (Nelson & Winter, 2009). This concept helps understand how team practices are changed by new tracking tools. When athletes communicate wellbeing data through self-report, they routinely distort that data in ways that help them save face, achieve their goals for training or play, or that help them avoid individual or team punishment. Staff are aware of and accept some of this distortion, and even account for it in their planning. In this routine, individual and team goals are balanced, and, in the words of Nelson and Winter:

> There is a truce between the supervisor and those supervised at every level in the organizational hierarchy: the usual amount of work gets done, reprimands and compliments are delivered with the usual frequency, and no demands are presented for major modifications in the terms of the relationship.
>
> —Nelson & Winter, *An Evolutionary Theory of Economic Change*

As described above, automated sensing limits athletes' ability to distort their data and, thus, to defy rules while limiting the consequences. This breaks existing routines, reducing behavioral discretion. To the extent that this reduces injury risk, it may be beneficial. However, current staff practices around training, whether athletes play, and punishments were developed based on data that could be distorted, and so they may be overly punitive for this new data source. It also may increase staff power in ways that athletes do not experience as positive, and, as we also saw in interviews, athletes are already developing new practices to distort sensor data and regain some of their autonomy.

4.6.2. Extraction Artifacts: Considering the implications of power asymmetry in coordination

I have shown and discussed situations where staff collect athlete data automatically or through self-report and where this collection is not by the athlete's choice and/or these data are not shared back to the athletes. Additionally, the borrowing artifacts created through these situations sit at the boundary between athletes and staff—the most significant power asymmetry we observed.

Lee defines borrowing artifacts by their procurement. Reflecting on the ways in which athlete data are collected—through devices with opaque uses that are opaque to athletes, through wellness surveys that must be complete or one's position on the team is in jeopardy—I suggest that "extraction" is a more precise characterization of the nature of the procurement described by participants than "borrowed." To reflect this nature of procurement and the power asymmetry around these artifacts, I propose a new kind of artifact that extends borrowing artifacts: **extraction artifacts**.

To develop this extension to the *boundary negotiating artifacts* theory, I first discuss the key differences driving this distinction of *extraction artifacts*, then I develop a definition of *extraction artifacts* as a type of *borrowing artifact*.

The first important distinction between extraction and borrowing artifacts is in the procurement of the artifact. Where borrowing artifacts appear in the study data, athletes cannot refuse the exchange of their data without risking their standing on the team. As athletes must give something to the staff, they may react by distorting the data before they share it (see Agency versus Surveillance and Obfuscation). Their ability to shape the data they share is reduced when the artifact is procured automatically. The nature of data exchange in these situations is one of extraction, even if sharing ultimately leads to benefits for both the athlete and the team.

As a second distinction, Lee's definition of the procurement of borrowing artifacts relies on the borrower being in a "trusted position whereby he or she has access to [the borrowed] artifacts and can

appropriate them... to further the goals of the project" (Lee, 2007). Staff members are in a trusted position and use the artifact to further the goals of the team. However, while the athletes or their bodies provide the data in the artifacts, the staff who designed the survey or chose to use the device define what is collected from the athlete and how. In this way, the staff extract the data from athletes rather than borrow an artifact the athletes have already prepared.

Finally, in Lee's example of borrowing artifacts, the borrower is not in a position of power: they are waiting on others for the artifact to borrow. The act of borrowing is positioned as a reclamation of agency as they re-purpose shared artifacts so that they can carry on with their job. These artifacts stand out because the positions of power are reversed. The staff, as borrowers or extractors, are in a position of power and use that position to extract the data needed for these artifacts—wellness survey results, reports on device data—hopefully, for the good of the team and the individual. Athletes are not in a position of power and cannot refuse the extraction without putting their relationships and standing on the team at risk; they can only distort the data they report.

Considering these distinctions, I define *extraction artifacts* as a type of *borrowing artifact* where the coordinator procuring the artifact is in a position of power. **Working from their position of power in the coordination, the extractor determines the way in which data are extracted from a person, often in ways that person has limited capacity to resist and for uses that may not be transparent to that person.** For personal data about athletes, such extraction often transcends existing boundaries, reaching into other contexts and even one's body.

The use of tools that produce extraction artifacts, such as automatic tracking devices, can exacerbate the power asymmetries associated with coordination. And, the use of tracking devices to automatically extract data from athletes, across a variety of contexts, diminishes athlete agency and increases staff control over athletes. Further, when these data are not shared with athletes, they may not even know what about them is being communicated to others.

4.6.3. Extraction Artifacts as a Lens into Coordination With Power Asymmetries

In considering how personal data are collected and used in collegiate sports teams, I found it helpful to define a new category of boundary negotiating artifact that better characterizes the power relationships I saw in the study data: extraction artifacts. I believe that extraction artifacts can help CSCW researchers and designers understand power and surveillance issues associated with various types of personal data.

Even though the extraction artifacts used by the athletic teams were created to support coordination (e.g., adapting a training plan based on how well rested a student-athletes is), they also became tools of surveillance. As with other types of surveillance (Zuboff, 1988), these tools then pushed student athletes to comply with staff or team expectations. Participating in tracking can help athletes achieve better individual and team performance and reduce risk of injury, while not participating could cause them to be excluded from games, practices, or even the team. As a result, they are strongly incentivized—if not compelled—to participate (A. E. Saw et al., 2015a, 2015c). However, athletes may not want or fully understand all of the consequences of surveillance, such as limited autonomy, lack of privacy, or psychological consequences of surveillance (Zweig, 2005).

This shift from a coordinating tool to a surveillance tool parallels other uses of personal data, e.g., in corporate or insurance wellness programs (Chung et al., 2016). Even a simple social program intended to promote awareness (and thus a norm) of physical activity can take on attributes of surveillance (Gorm & Shklovski, 2016). It raises questions about at what point previously studied tools—such as those for sharing physical activity and nutrition data with one's health provider to access better expert advice and accountability (Kim et al., 2016)—become surveillance tools. Key distinctions may be in whether artifacts are borrowed, whether they are artifacts designed to extract information, and in the relative power of individuals in coordination.

I anticipate that this lens may be similarly helpful for studying other situations in which personal data are collected, including uses that already have more overt surveillance efforts. For example,

workplaces monitor and surveil their employees to reduce costs or gain productivity (Mathur et al., 2015; Meyer et al., 2017; Zhao et al., 2017). Designers and researchers seeking to shift this relationship back from one of surveillance (e.g., who is productive?) to one of coordination (e.g., how can we help you succeed at work?) may consider how to shift from designing tools that are extraction artifacts into designing other types, such as borrowing or inclusion artifacts.

This is not to say that extraction artifacts are always problematic. When team staff design a survey or a data collection tool, they are able to ensure they get the information they need to support their decision making. Similarly, health-tracking researchers have recommended that clinicians contribute their medical expertise to the selection of tracking tools (Chung et al., 2016), again so that the resulting data support the decision-making process.

I also see the value of extraction artifacts in other contexts. For example, delivery and long-haul truck drivers are tracked throughout their days using GPS (Apostolopoulos et al., 2014; Roetting et al., 2003). Such tracking can promote public safety (e.g., by ensuring rest requirements are met) and it can also be experienced as an oppressive form of scientific management. Additionally, the use of police body cameras to track interactions with the public (Coudert et al., 2015) purposefully disrupts longstanding power asymmetries that have favored police.

CHAPTER 5

Speculating the Futures of Sports Technology (Study 2a, Design)

Based on my investigation of current practices, I found a need to imagine alternative futures for tracking in collegiate athletics. Using a discursive design approach, a group of students and I designed three speculative videos to learn about the college athletic community's preferred futures for the design and use of sports tracking technologies. I will describe the results of this investigation over two chapters. This chapter will describe the video design process that was conducted from January 2021 through June 2021 and what was learned from this process.

5.1. Introduction & Motivation

My investigation of current tracking practices and coordination around data revealed a need to figure out how to design and use tracking technologies in a way that balances the goals of different roles around tracking data. Tracking technology design and use should also not reinforce power dynamics, especially the coach's power over athletes, and should not support the current extractive data collection practices.

The current rapid design and adoption of tracking technologies for sports teams presents an opportunity to disrupt current social dynamics on teams and reimagine ways to design tracking technology that support the needs of multiple roles rather than reinforcing power dynamics. To address this opportunity, this study shifts the focus from current to future design and use of tracking technology.

Speculative Design invites designers and audiences to think about the futures they want and do not want. As Dunne and Raby said (Dunne & Raby, 2013):

> This is the bit we are interested in. Not in trying to predict the future but in **using design to open up all sorts of possibilities that can be discussed, debated, and used to collectively define a preferable future for a given group of people**: from companies, to cities, to societies. Designers should not define futures for everyone else but working with experts, including ethicists, political scientists, economists, and so on, generate futures that act as catalysts for public debate and discussion about the kinds of futures people really want.
>
> —Dunne & Raby, *Speculative Everything*

This is the bit I am interested in too. Using design to put forward possibilities for balancing the needs and goals of student-athletes and coaches through the design and use of sports tracking technology that can be discussed, debated, and used to identify preferable futures (see Figure 2)—what the college athletics community wants and does not want—for the design and use of sports tracking technology in college sports. In other words, this study will answer the question: ***What are the college athletic community's preferred futures for the design and use of tracking technology?***

However, studying the entire U.S. college athletic community and every possible facet of preferred futures for the design and use of tracking technology on college sports teams is a large scope. To narrow the scope, this study will focus on interactions between student-athletes and coaches around tracking technology and the preferred futures for the design and use for these roles.

The rest of this chapter will describe how I began addressing the research question above through the design and production of three short speculative videos. These videos were created over the course of six months in an HCDE Directed Research Group (DRG) (Turns & Ramey, 2006) involving a multidisciplinary team including four student-athletes, four design students, and three HCDE students (see Appendix I.B for a list of students). Each video contains knowledge about preferred or not preferred futures for the design and use of tracking technologies and aims to provoke critical thinking around these futures.

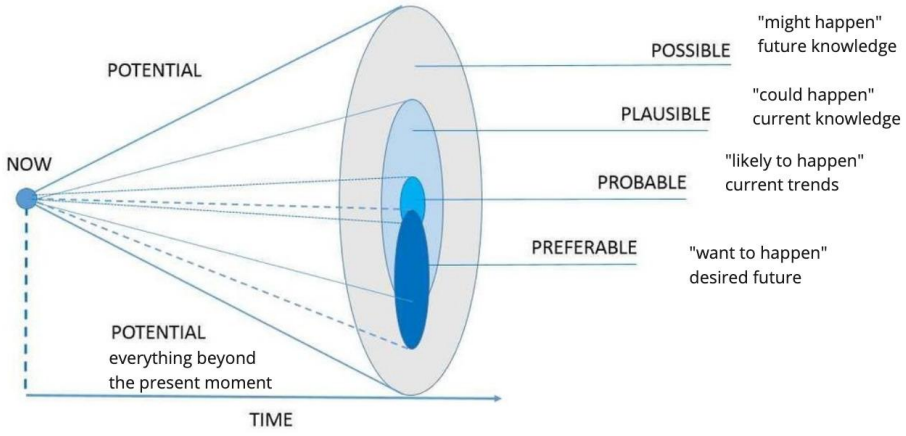


Figure 2. Voros's Futures Cone (Voros, 2003). Speculative Designs explore preferable futures that people "want to happen."

5.2. Methodology: Discursive Design

This section will describe the methodology used in this study. My overall approach combines:

- A research through design approach (Zimmerman & Forlizzi, 2014) that creates new knowledge through the design process and embeds this knowledge in the design artifacts.
- A Discursive Design approach (Tharp & Tharp, 2019) to spark discussion and reflection around preferred futures for the design and use of sports tracking technologies. This approach also draws on: Critical Design (Dunne & Raby, 2013) to critique the current designs that reinforce power dynamics and extractive data collection practice and Speculative Design (Auger, 2013; Dunne & Raby, 2013) to look to the future for ideas on how to design and use tracking technology in ways that do not reinforce power dynamics and extractive data collection practices, and instead balances the goals and needs of student-athletes, coaches, and the team.
- The use of video prototyping (see Section 5.2.3) to tell a story and convey knowledge about preferred or not preferred futures.

- A participatory approach (Muller & Druin, 2003) that involves student-athletes in the design process.

5.2.1. Defining Discursive Design

Discursive Design is a relatively young field of design and so its methods are evolving and it is still finding its place in the fields of art and design. The authors whose work influences my approach all use different terms or hierarchies of terms to describe their ideas and methods (Auger, 2013; Dunne & Raby, 2013; Tharp & Tharp, 2019). I doubt whether they could all agree on the definitions of discursive, critical, or speculative design or a mapping of how these approaches and their related fields intersect. Nevertheless, I will posit my own understanding and position based on these authors' works so I can position my own work.

I consider Research through Design (RtD) to be the root of my approach. RtD is "an approach to conducting scholarly research that employs the methods, practices, and processes of design practice with the intention of generating new knowledge" (Zimmerman & Forlizzi, 2014). More simply RtD connects research and design and focuses on investigations of the future to "understand the world that should be brought into being."

The contributions of Study 2 are based on the key idea of RtD: that design artifacts and the process of creating them can construct forms of design knowledge (Zimmerman & Forlizzi, 2014)**.**

RtD includes three practices to choose from: *lab*, *field*, and *showroom*. My approach combines the *field* and *showroom*, where the *field* practice is based on participatory design in Scandinavia and user-centered design in the U.S. and the *showroom* practice is based on discursive design, critical design and speculative design. I will elaborate on the participatory and user-centered parts of my approach in the next section in discussing my design process. Here I will continue to position my study within discursive, critical, and speculative design.

Tharp and Tharp position Discursive Design as an umbrella for many other related types of undesign[16] including critical design and speculative design. I tend to agree with this hierarchy because **Tharp and Tharp define discourse as a system of thought or knowledge "capable of sustaining a complex of competing perspectives and values."** This definition is derived from Foucault who defined discourse as "ways of constituting knowledge, together with the social practices, forms of subjectivity and power relations which inhere in such knowledges and relations between them" (Weedon, 1987).

College athletics use of tracking technology can be thought of as a discourse which Chapter 4 shows is a complex of competing perspectives and values. Additionally, in the next section I will describe how we used these competing perspectives and value tensions to build the video narratives produced in this study.

5.2.2. Defining my approach with nine facets of Discursive Design

Now that I have established my perspective on these dizzying, overlapping perspectives and where I think my work fits in, I employ Tharp and Tharp's framework of nine facets for Discursive Design (Tharp & Tharp, 2019) to further outline my approach for this study and along the way I show where other key Speculative Design concepts from Auger fit into this framework (See Table 4).

[16] Term used by Dunne and Raby to describe types of design when "designers step away from industrial production and the marketplace we enter the realm of the unreal, the fictional, or what we prefer to think of as conceptual design—design about ideas."

Facet Definition	How the facet is employed
1. **Intention.** Reflection is the baseline intention for a discursive design but Tharp and Tharp believe a discursive designer's work has intention in its mindsets and aims. They define five mindsets and five aims for discursive design.	I take a **suggestive** mindset as a designer in asserting my opinion based on the evidence gathered from previous work, my own experience, and the experience of my collaborators. I also seek to present my evidence-based opinions to **disrupt** and shift the conversation around tracking technologies in sport to how they *should be* designed and used. I also take an **inquisitive** mindset because knowledgeable as I am about college athletics, I do not feel I have all the answers and I am hoping to use the discursive designs as a means of inquiry. Through the videos, I aim to **provoke** a response from and **persuade** the college athletics community to shift conversation around tracking technologies. I want the videos/narratives produced in this project to incite discussion about how tracking technologies should be designed and adopted.
2. **Understanding.** This facet suggests discursive design is more effective when the designer has a better understanding of what is being communicated. Tharp and Tharp argue that a designer has an **ethical responsibility** to know about the discourses being conveyed so misinformation is not spread, that **efficacy** both in design methods and the audience is needed to make an impact, and the designer needs to have **credibility** so that they are trusted and taken seriously.	Chapter 2 conveys my personal credibility with the context. Additionally, I have five years of experience studying human-centered design and five studying computer science which speak to my credibility as a designer who understands how technology is built. Chapter 3 and Chapter 5 convey my in-depth understanding of college athletics and my understanding gathered from the data I have collected about the use of tracking technology in college athletics. For this project, I also engage collaborators who are current student-athletes and design students to check my understanding of both design and college athletics.

Facet Definition	How the facet is employed
3. Message. This facet consists of message-content and message-form. Defining the message is important because as Tharp and Tharp write: "The point of discursive design is to leverage the advantages of objects as a differently powerful means of communication. Loss of exactness is the price that is paid."	The **message content** or the intended discourse for each video differs between each of the three videos designed as part of this project. Section 5.4 defines a message for each video. The **message-form** refers to how the message is conveyed. A key part of this project is how each video will use a different **example** to convey different ideas within the discourse. Each video will also convey a different **narrative** about what could happen including **cause and effect** situations where the outcome is affected by how the **example** technology is designed or used.
4. Scenario. Every discursive design should present a scenario that tells a story. Both Auger and Tharp and Tharp agree that a crucial quality of effective discursive design is a *discursive dissonance* or an *uncanny.* This quality is somewhat undefinable but should make the audience slightly uncomfortable, feel a resonance of familiarity, question the reality, truth or desirability of the scenario. It is this quality that makes the audience think and incites reflection. Tharp and Tharp define five dimensions that can be "dialed" to produce an effective scenario: **clarity**, **reality**, **familiarity**, **veracity**, and **desirability**.	In this project, there are three scenarios presented through three different videos. In designing the video we aimed to carefully craft scenarios that were **clear** where necessary but also employed the power of ambiguity so that the audience may take away different interpretations to discuss. Keeping some details ambiguous was also purposeful in leaving the audience to decide whether or not the scenario was **desirable**. Overall, we did not intend that any of the scenarios be wholly desirable, but we intended that the audience find some elements preferable and some not. We also intended that each scenario include a good level of **familiarity** in both the technology and interactions between athletes, teammates, and coaches shown on screen. None of the scenarios play with **reality** or **veracity**.

Facet Definition	How the facet is employed
5. Artifact. This facet refers to all the artifacts that make up a discursive design project. This study created videos that tell the story (*depictive artifacts*), a website or other display for the videos and supporting information describing the design process (*explanatory artifacts*), speculative technologies (*principal artifacts*) that support the telling of the story (*explicit scenario*).	Tharp and Tharp define the same five dimensions as scenarios that can be "dialed" to produce an effective discursive artifact. The intentions for each of these dimensions are the same as with the scenarios. The speculative artifacts were intended to include ambiguity, be realistic, familiar, truthful, and have questionable desirability.
6. Audience. In the most straightforward of all nine facets, it is important to define the audience and their relationship to the artifact(s).	The intended audience for the discursive designs produced in this project was the college athletics community.
7. Context/Dissemination. Tharp and Tharp define four considerations for the context of dissemination for discursive projects: **attention**, **meaning**, **mood**, and **management**.	College athletes, coaches, and others in college athletics are often at the limit of their **attention** span which can make it difficult to get their attention. I focused on disseminating these videos in a study environment to capture responses because this would ensure undivided attention. During the study sessions we presented the videos as neutrally as possible so that the audience could form their response based on the design rather than the **mood** of the designers. Further discussion of the dissemination and how it was **managed** can be found in Chapter 7.

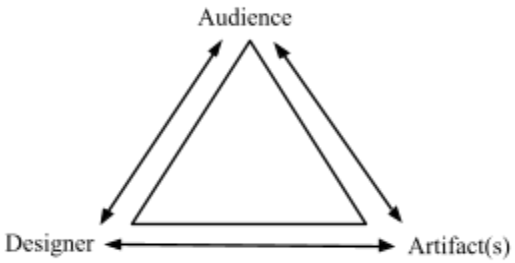
Facet Definition	How the facet is employed
8. Interaction. This facet describes a triangle of interactions between the designer, artifact, and audience (Tharp & Tharp, 2019).  **Figure 3.** Triangle of interaction.	This study includes interactions on all three sides. **Audience ←→ Artifacts.** Chapter 7 describes the results of the interactions between the audience and the videos (artifacts). **Designers ←→ Artifacts.** The rest of this chapter describes the design process, in other words, the interactions between the designers and the artifacts. **Audience ←→ Designers.** The interactions between the designers and the audience occurred during study sessions described in Chapter 7 and online (see Appendix III).
9. Impact. The ninth and last facet concerns the impact of a discursive design. Tharp and Tharp describe possible *business* and *professional* impact as well as *social engagement, practical application, applied research, and basic research.*	The videos had applied *research* impacts because I will be intentionally creating opportunities to collect the audience's *relevant thinking* and *relevant responses* through dialogue with the designers. This resulted in *actionable insights* during my analysis (see Chapter 6).

Table 4. How I employed Tharp and Tharp's framework of nine facets for Discursive Design to structure my approach for Study 2.

5.2.3. Video Prototyping

Discursive Design can take different forms and its methods can be vague and so difficult to conduct (Bardzell & Bardzell, 2013). Auger even states that he thinks defining methods for Speculative Design is impossible (Auger, 2013). However, as I outlined in the previous section, Tharp and Tharp's nine facets of discursive design are helpful for defining a discursive design project. However, I also purposefully chose **video prototyping** as the medium for discursive design. Video prototyping combines design and storytelling with visual communication.

I chose to use video prototyping as the method for this project for several reasons. First, videos are a great way to reach my audience—busy student-athletes, coaches, staff, and athletic organization

employees who are unlikely to read a long academic publication that does not appear in a sports science journal. Second, I felt that storytelling was necessary to draw in the audience, convey the value tensions around tracking technologies, and help the audience have a sense of familiarity. And third, video as a medium affords suspension of disbelief as video prototyping enables the representation of complex future technology through use of video techniques and effects.[17]

I was further specifically influenced by two speculative video projects created by the design group Superflux[18]: *Uninvited Guests*[19] and *Our Friends Electric*[20] (Rogers et al., 2019).

Uninvited guests

As a story of interpersonal tracking, *Uninvited Guests* has a clear connection to the context of my work:

> Thomas, aged 70, lives on his own after his wife died last year. His children send him smart devices to track and monitor his diet, health and sleep from a distance. But Thomas has always been fiercely independent, happy to live in an organized mess. He struggles with the order and rules imposed on him by the objects that are meant to make his life easier. In a world where 'smart objects' will increasingly be used to provide care at a distance, how will we live with these uninvited guests?

The tensions in the scenario of agency versus surveillance and trust versus accountability are analogous to the tensions I observed in Study 1. Additionally, at the turning point of the video, Thomas uses *obfuscation* strategies to continue his old habits while fooling his children into thinking his behaviors have changed. For example, Figure 4 shows a series of video stills showing that Thomas is reaching his daily step goal by giving his smart cane to a boy who runs around with it and is compensated for his time with a beer. In Study 1, one staff member suspected that a student-athlete gave his sleep tracker to someone else while he went out to a party. The similarities between *Uninvited Guests* and the findings

[17] For an over-the-top example of this see: hyper-reality.
[18] Founded in 2009 by Anab Jain and Jon Ardern, Superflux is a design group that creates "worlds, stories, and tools that provoke and inspire us to engage with the precarity of our rapidly changing world." For more see https://superflux.in/#.
[19] Watch the *Uninvited Guests* video here: https://superflux.in/index.php/work/uninvited-guests/#
[20] What the *Our Friends Electric* videos here: https://superflux.in/index.php/work/friends-electric/#

from Study 1 confirmed that it would be possible to convey the nuanced tensions I observed in Study 1 through a video.

Figure 4. Video stills from *Uninvited Guests*. In this scene, Thomas has given his smart cane to a boy who gained the goal number of steps with the cane in return for a beer.

However, my key takeaway from *Uninvited Guests* was more than the effective storytelling, it was **the use of simple everyday objects and simple video animations and effects to illustrate a speculative technology.** The smart objects in the video are merely everyday objects spray painted yellow so that they stick out and it is clear they are part of a collective set. And the simple video animations convey what these objects are tracking and the communications between Thomas and his children. The idea that a cane could track steps is familiar, but in this form I can suspend my disbelief that a simple fork could track nutrients in food just by touching it.

In the design of the methods for this study, I planned for the research team to try experiments at home where they created video sketches[21] showing everyday objects as speculative. This ultimately inspired the design ideas and artifacts portrayed in the final videos for this study.

Our Friends Electric (Rogers et al., 2019)

In this project, Superflux combined speculative design, product design, videography to explore values around voice interaction products (e.g., Alexa, Google Home). The goal of the project was to advocate for "healthier" implementations of voice technologies and convey the abstract values surrounding these technologies—trust, privacy, security, legibility, and agency.

Figure 5. Designs from *Our Friends Electric*. From left to right: Karma, Eddi, and Sig.

Their approach and execution of their process inspired the approach and process I used in this study. First, the end result of the project was three videos that portray separate but related speculative scenarios that each center on a different speculative voice interaction technology. Figure 5 shows a picture of these three technologies. I chose the goal of three videos so I could illustrate more than one of the tensions that I observed in Study 1 and hopefully capture more of the nuances involved.

[21] A term I made up for referring to TikTok-like short videos that the research team were asked to create during the course of the design process (see Section 6.4 and the syllabus in Appendix II.C).

Second, Superflux brought together a team of experts relevant to the project to discuss the values, themes, and important ideas that the designs and scenarios should convey. My approach is similar, though my research team is composed of students; they are student-athletes, designers, and videographers who have skills and expertise relevant to the study. Also, my approach differs because the research team is involved in every stage of the process: ideation, design, and video production.

Third, I use a similar overall design process. The main difference is that I do not specifically use product design methods and never intended to create physical designs of the speculative technologies featured in the videos produced for this study. I substitute the high-fidelity designs with the approach of *Uninvited Guests* and use everyday objects and video prototyping techniques.

Lastly, with *Our Friends Electric*, Superflux took an additional step not always taken by discursive designers: analyzing reactions to their work. In projects like the Obscura 1C Digital Camera and the Audio Tooth Implant, the designers put their artifacts out in the world but did not evaluate any reactions to their designs. I was frustrated by the reaction of James Auger to his Audio Tooth Implant featured in Time magazine as one of the coolest inventions of 2002 (Auger, 2013). In his paper *Crafting the Speculation*, Auger not only distributes the technology as if it is real, he does not seem to mind distributing misleading information and does not correct the inaccurate coverage by *Wired* or *Time*.

I aimed to distribute the videos produced in this study in a way that sparks reflection and discussion but also in an ethical way that does not spread misinformation. Additionally, like *Our Friends Electric*, I aimed to analyze the reactions to the videos (See Chapter 6).

5.3. Design Process

This section will describe the design and development processes conducted with a multi-disciplinary team including four student-athletes, four design students, and three HCDE students (see Appendix II.B for a list of students) in a six month Directed Research Group (DRG) (Turns & Ramey, 2006) that took place

from January 2021 through June 2021. Throughout this section I will interchangeably refer to this group of students as the 'research team' or 'the students' because it is important to remember that the designers of the videos for this project are both students and researchers.

At the beginning of Section 5.2, I state that Research through Design is the root of the methods and approach I am applying here. **Therefore, part of the knowledge creation and contribution of this study is the design process.** Through the rest of this chapter I will aim to highlight what knowledge was created from the process that addresses the research question for this study or the larger aims of this dissertation.

5.3.1. Design Phase (January - March 2021)

The goal for this quarter and the design phase of the project was to design three concepts that we (the research team) would develop into short videos in the next phase of the project. Each concept needed a central tension between a student-athlete, a coach, and tracking data (e.g., trust vs. accountability) that the video would critique, a speculative technology that can help highlight this tension, a storyboard to explain the scenario, and descriptions of the main characters and their values.

To be able to guide the research team in creating these concepts, I carefully designed a plan[22] for the 10 week quarter (for a week-by-week syllabus, details of the assigned activities, and assigned readings, see Appendix II.C). As this work was completed in January through March 2021, the research group met virtually via Zoom once per week for two hours and used Miro boards to organize and collaborate on ideas. The online format worked just as well if not better than if we were able to meet in person. Miro board supports a permanence of ideas that an in-person environment does not and allows easy organization and reorganization of ideas, sketches, and other artifacts.

[22] In designing my plan for this quarter, I consulted Tyler Fox and Audrey Desjardins who have experience with Speculative Design and provided some resources and ideas for improving the design process. I also consulted Kristin Dew who has experience with Speculative Design and with running a multi-quarter DRG as part of her dissertation work.

Introduction to the project and speculative design

The first three weeks of the design phase were dedicated to teaching the students about Discursive Design and to introducing the students to the project and my findings from Study 1. Two key activities from these weeks produced some initial knowledge as to how tracking technologies should be designed and used on college sports teams that became embedded in the videos.

First, a *preferred future* emerged around athletes having control over their tracking data and a choice about whether or not to share their data with their coach. This preferred future emerged through a video sketching activity the research team did. The goal of these video sketches, which they were encouraged to think of like TikTok videos, was to help them think about artifacts in their environment differently and explore Speculative Design ideas. One sketch took a first person view as an athlete puts on a contact lens, goes for a run, and then is asked in an augmented reality interface (demonstrated by slips of white paper) if they would like to share their data with their coach. Athletes having control over their data was not found in the current practices discussed in Study 1, but this idea responded to athletes' lack of control over their data that was discussed in Study 1. The research team felt that control over data was a *preferred future* and this idea was embedded in Video #3: EnVisible. The contact lens technology in this video also went on to be featured in Video #1: Informonocle, though it was not chosen because it was something the research team felt was *preferred*.

Second, the research team identified values that they believed athletes and coaches hold and should be considered in the design and use of tracking technology. These values were identified through the value dams and flows exercise adapted from the Value Sensitive Design methodology (VSD) (J. Miller et al., 2007; Nathan et al., 2007). The value dams and flows exercise begins with identifying values and stakeholders. Once values and stakeholders are identified, the exercise continues with focusing on one stakeholder at a time and identifying possible benefits and harms of a technology for that stakeholder and the values associated with those benefits and harms. For this exercise we also drew upon findings and

interview data from Study 1 and the lived experience of the student-athlete researchers in our group to identify values that student-athletes and coaches may hold and the values tensions between these roles.

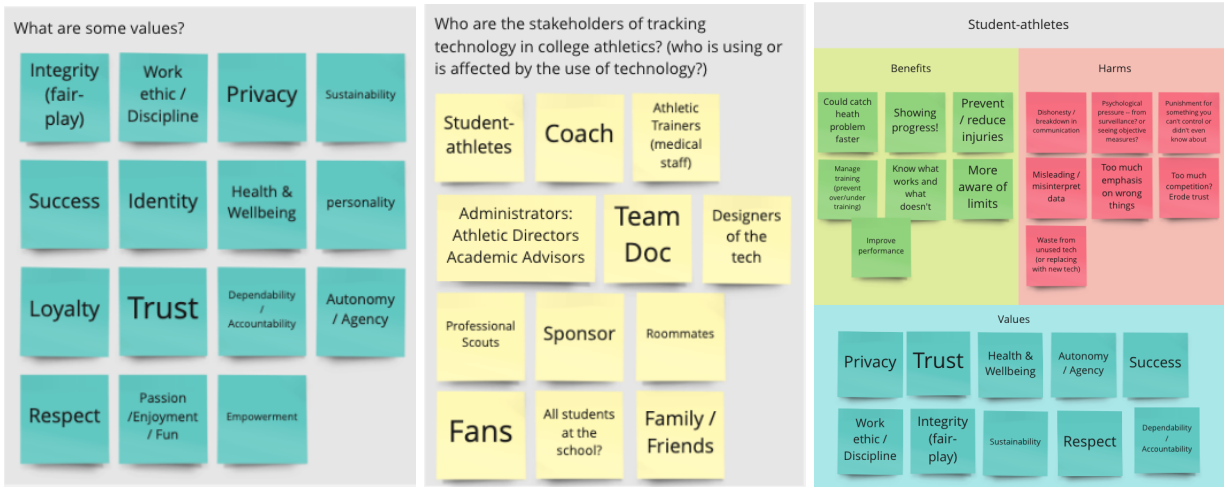


Figure 6. Screenshots of the value dams and flows exercise. The first screenshot on the left is where we identified values. The second screenshot in the middle is where we identified the stakeholders. And the third screenshot on the right is of our focus on student-athletes with the benefits in green, the harms in red, and associated values in blue. Like previous images in this section, these images are intended to convey the structure of the exercise, the smaller text is not intended to be read.

Many of the values identified, such as trust and accountability, were discussed in Study 1. However, in identifying them here the research team was affirming that these values should be taken into account in the *preferred futures* for the design and use of tracking technology in college athletics. The research team also emphasized the value of integrity and how tracking data may support or corrupt the integrity of athletes and coaches, and the importance of supporting athlete health and wellbeing in the design and use of tracking technology. The knowledge that these values and the tensions between them are important for the design and use of tracking technologies in college sports are embedded into the videos.

Ideation

The next part of the design phase was dedicated to ideation to identify promising ideas for the videos. To ensure a range of ideas, each member of the research team sketched 20 ideas including ideas for speculative technologies, preferred and not preferred use cases, and the best and worst ideas for

technologies and use cases. This generated over 200 ideas. After reviewing the sketches, each member of the research team sketched storyboards that built off of the ideas in the sketches.

Ideation was both unsurprising and brought forward some new knowledge. I found the ideas for speculative technology were unsurprising as they ranged from predictable futuristic ideas to some fresh ideas such as an organ wrap tracking technology. There were also unsurprisingly plenty of sketches about surveillance and getting overloaded by data. However, the sketches surfaced ideas about data visibility and comparison that constituted new knowledge about possible preferred or nonpreferred futures. This knowledge that data visibility should be considered in the design and use of tracking technology for college sports teams is embedded in Video #3: EnVisible and created a new line of thinking that led to visibility becoming a heuristic in the contribution of this dissertation. I want to draw attention to Figure 7c as it was not specifically represented in any of the videos but based on the reactions to the videos described in Chapter 7, this is a preferred future that I believe to be promising to balance the needs of coaches and athletes (See Section 7.4.2).

Additionally, even sketches that reinforced an idea discussed in Study 1 or put forward ideas for a best use case that might seem obvious (see Figure 8b) constituted knowledge about how tracking technology should be designed and used for college sports. The obvious nature or simplicity of some of the best use cases may also point to how lacking current practices and tracking technologies are in supporting the needs of athletes or the social dynamics of teams. For example, Figure 8b follows from the suggestion in Study 1 that tracking technology should better support coordination between coaches and athletes. Open communication to help athletes reach their potential may seem obvious, but as it was even suggested as an idea means that it is lacking.

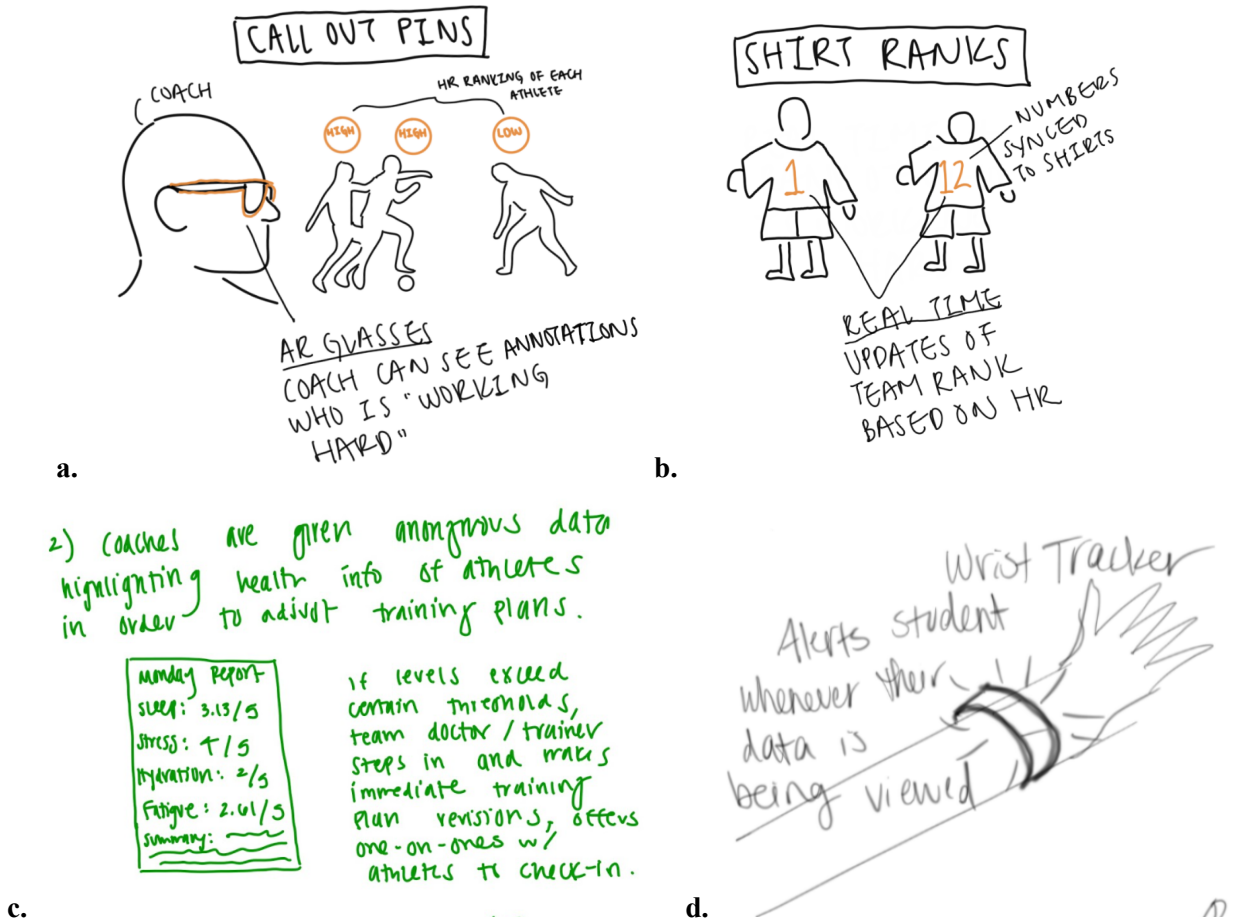


Figure 7a-d. Sketches that focused on data access, visibility, surveillance, and comparison that inspired the themes for Video #1: Informonocle and Video #3: EnVisible. Sketches (**a)** and (**b)** depict similar ideas of visibility where a coach or the whole team can see a ranking of athletes by their heart rate data, a non preferred future because heart rate is such an individual measure. Sketch (**c)** describes a preferred future where data is visible to the coaches anonymously to protect athlete privacy but coaches still have enough information to adjust training and if the athletes health data reaches a certain threshold then steps can be taken to involve staff members to help the athlete. Sketch (**d)** depicts a non-preferred technology that lights up to alert the athlete that their data is being viewed by the coach.

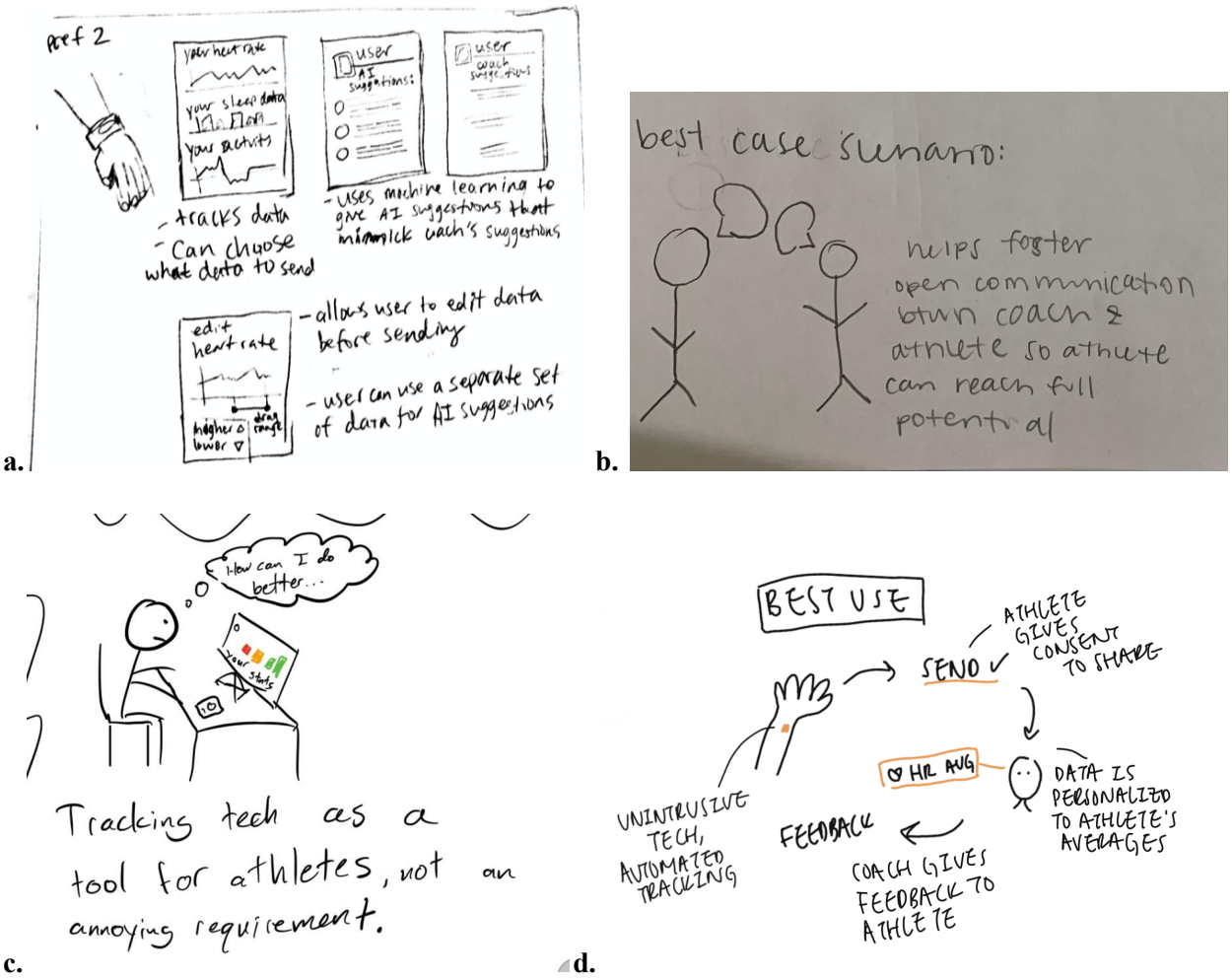


Figure 8a-d. Sketches from ideation that represent best use cases for tracking technology. All of these ideas were either incorporated into the videos or are part of a preferred future described in the reactions to the videos (Chapter 7). Sketch (**a)** suggests a preferred future where athletes can choose what data to share, using AI and machine learning to make suggestions to the athlete and coach, and allowing users to edit data before sharing. Sketch (**b)** depicts a preferred future where tracking data "helps foster open communication between coach and athlete so athletes can reach their full potential." Sketch (**c)** shows an athlete reviewing their data looking for how to do better and suggests that "tracking tech as a tool for athletes, not an annoying requirement." Sketch (**d)** suggested a general preferred use cycle for tracking data where the data is collected automatically and unobtrusively, then sent to the coach if the athlete consents, then is used for personalizing training for each athlete, and finally the coach is able to give feedback to athletes.

Concept Development

Following ideation the research team had a discussion to identify three themes or value tensions to move forward with that would be the root of a video concept. Once the three themes were agreed upon, the research team divided into smaller teams that worked together to develop one of the video concepts. Drawing on the ideas we had already created, each team collaborated on a storyboard for their video and a speculative technology that their story would feature to highlight their team's tensions. Each team was specifically asked to produce a summary of their proposed video, a statement about the preferred future and value tensions they would portray, a summary of the speculative technology they would portray, a paragraph describing the scenario they would portray, a storyboard laying out the proposed video, and descriptions of the characters in their video. The teams presented their final concepts for feedback at the end of the design phase (See full presentations in Appendix II.E).

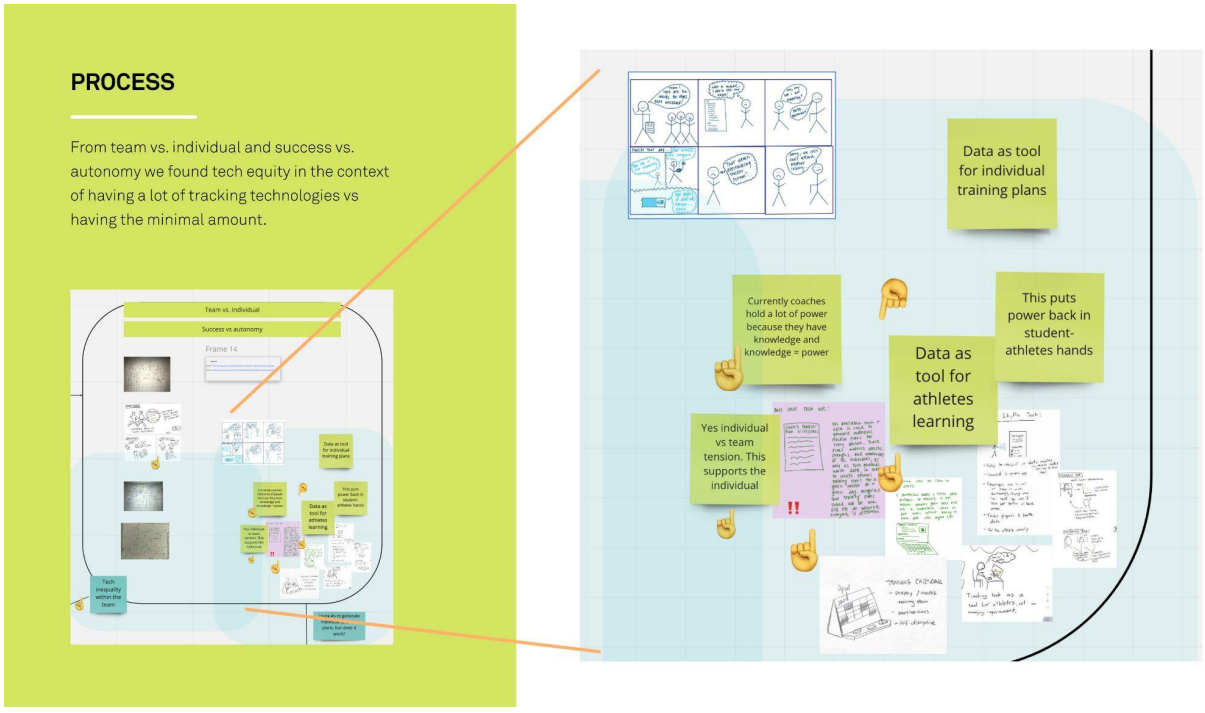


Figure 9. This image was taken from one of the presentations at the end of the design phase. The image on the left shows a portion of the artifact created by the discussion to identify video themes and the image on the right is zoomed in to show one of the thematic areas that was developed into a video concept.

Section 5.4 will go into detail about each of the final video concepts, so here I will briefly state the knowledge that was created through the design phase that became embedded in the videos:

Video	Preferred Future	Not Preferred Future	Open for discussion
Video #1: Informonocle	A data-informed approach which emphasizes balance so that student-athletes are not put under additional pressure and can still make decisions that are in the interest of their personal wellbeing.	A data-driven approach limits a student-athlete's autonomy to make their own decisions. Also how this may impact a student-athlete's mental health and/or lead a student-athlete to 'cheat the system' or use strategies of obfuscation such as lying or somehow producing fake data to manage how their coach views them.	
Video #2: Clippits	Using data to drive personalized training insights and create individualized training plans for student-athletes. Also how athletes and coaches could use data as a tool for learning.	A technology inequity where some teams or individuals might have more access to technology than others or a power dynamic reinforced by having access to data (knowledge is power).	How much data is too much?
Video #3: EnVisible	Athletes having control over their data and deciding whether or not to share it with their coach.	Reduced trust or accountability due to not sharing data with a coach or between teammates.	Should team success or individual agency come first? Do athletes have a choice to share their data?

Table 5. Summary of knowledge about preferred or not preferred futures that were embedded into the videos. Two of the videos also included questions about what is preferred in the video's intended message.

5.3.2. Development Phase (March - June 2021)

The goal for this phase was to develop three speculative videos based on the concepts proposed by each team in the design phase (See the previous section and the detailed syllabus in Appendix II.D). To ensure successful video development, each team further developed their concepts through writing a script, planning how the speculative technology would appear on screen, and creating a shot list that would provide structure on how to shoot each shot that would make up the video.

Each team's process for video production was different and challenging due to the coronavirus limiting how we were able to shoot video, but still roughly followed a similar schedule. Two weeks were spent writing and iterating on a script based on the storyboard from the end of the design phase. Once the script was coming together, each team was able to start on a shot list where they listed out every shot we would need to take to create the video. As each team was finalizing their script and shot list, they also scheduled shoots, recruited actors, and gathered props and other equipment to prepare for shooting.

Teams then had two or three weeks for shooting depending on how long it took them to finalize their script and shot list. Minimal equipment was used to shoot all three videos. All three videos were shot with iPhones set up on tripods, except one video which had a few drone shots, and we used lapel microphones and shotgun microphones to capture audio. All the equipment we used was pre-owned by one of the research team members or borrowed. Once most or all of the footage for a team's video was shot, the remainder of the quarter was spent editing and organizing materials to present alongside the videos.

5.4. Final Video Prototypes

In this section, I will revisit the message and scenario facets of Tharp and Tharp's discursive design framework to describe each video as a discursive artifact and what knowledge is embedded in the videos.

5.4.1. Video #1: Informonocle

In this section, I will describe the speculative technology in this video (the Informonocle), the scenario (what happens in the video), and the message that we wanted the video to convey which contains the embedded knowledge. **The Informonocle video can be viewed here: https://bit.ly/informonocle1.**

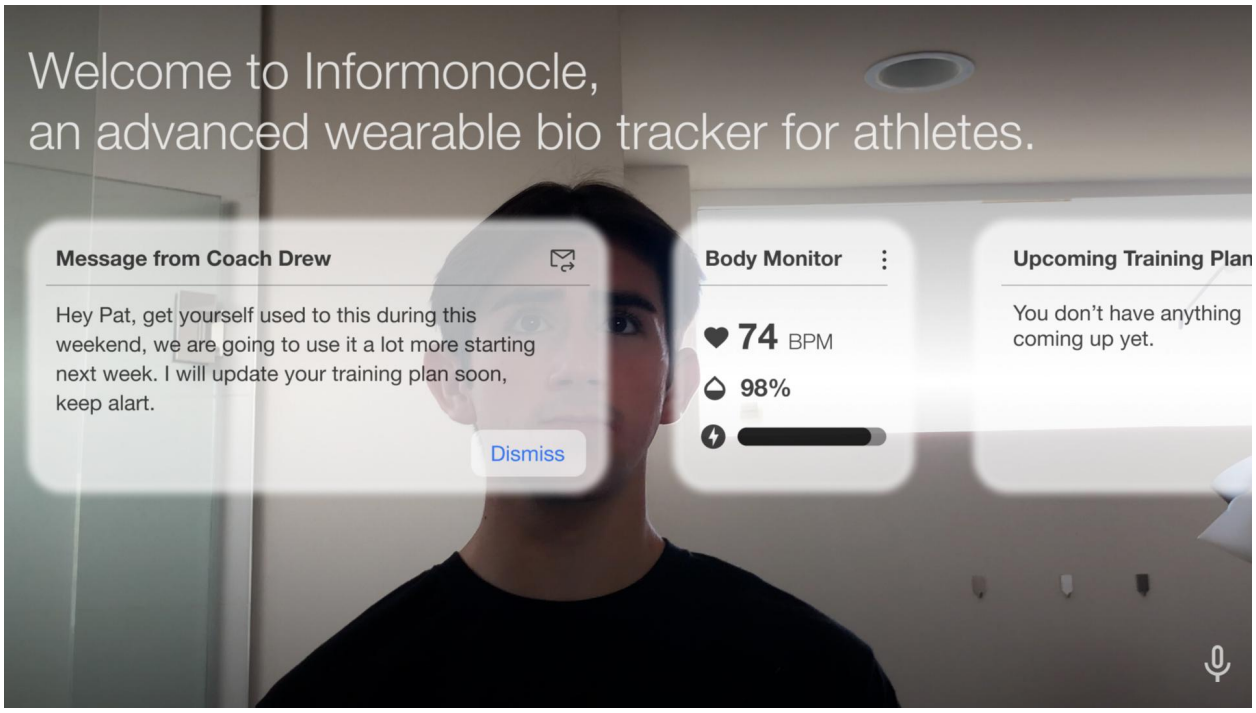


Figure 10. Still image captured from Video #1: Informonocle. The image shows the Informonocle interface when the main character first puts on his Informonocle.

The Speculative Technology: What is the Informonocle?

The Informonocle is a wearable device in the form of a contact lens that is worn in one eye. While wearing the Informonocle the user sees information in an augmented reality (AR). As Figure 10 shows below, an athlete could see messages, information about their body, and information about their team's training plan or calendar. The user can interact with the Informonocle interface using gestures and voice commands. The Informonocle also includes a contact lens or set of glasses for the coach or other staff members to wear. Though it is not shown in the video, the intention for this technology is for coaches and staff to be able to see their athletes data in real time as well as interact with it in an AR view.

At the time the video was created, technology close to the Informonocle seemed to be from a further future. However, since then a company called Mojo Vision has started working on an AR contact lens. Though this would still be far from the contact lens being able to track someone's heart rate without additional technology, the idea now seems more within reach.

The Speculative Scenario: What happens in the video?

This video is set in the near future where tracking technology is small and advanced enough to fit in a contact lens. However, this is not so far in the future that there were any other unfamiliar changes. The scenario portrayed in the video focuses on a college track and field team and specifically on two athletes, Pat and Alex, and their coach. Where the scenario starts, the coach is feeling like his team has untapped potential and believes that technology is the answer for improving his team and helping him make more data-driven decisions.

The coach introduces the Informonocle to the team and in a key scene Pat and two teammates discuss how they initially feel about the new technology. Pat thinks it will show his coach how hard he has been working while his teammates are worried about when they will study if they can no longer choose to skip the optional secondary training sessions in the afternoon. The next day Pat tries on the Informonocle for the first time (see Figure 10). He is able to see messages from his coach, his heart rate, his energy level, his hydration level, and upcoming training sessions.

After a while, Pat's teammate and star runner Alex is feeling like his knee might need some rest, but the coach pushes him to finish practice anyways. When Alex ends up injured and out for the next ten weeks both him and Pat blame the new data-driven approach to training led by the coach and the Informonocle. Concerned that he might end up injured like Alex, Pat complains to his roommate about the Informonocle. Pat's roommate suggests trying to hack the device and send fake data to his coach. Together Pat and his roommate find a way to hack the Informononcle.

Pat tests the hack on an afternoon run and even though he slows down and walks home, the Informonocle data shows he is still running. Pat continues to use the hack when he needs it to get some rest and protect his mental and physical wellbeing. After a few weeks of using this hack when he needs to, Pat is feeling less burnt out and decides not to use the hack while out for a run and instead completes the run.

The scenario concludes with a series of short scenes to show the outcome of all of this from the perspective of the three main characters. Pat sees messages from his teammates on the Informonocle saying that they are feeling overtrained and replies letting them know that he has found a way to hack it. The coach finishes his day exhausted, but starts looking through the data as he needs to make a decision about who will replace Alex on the relay team in their next competition. In a brief call the coach complains about the amount of data he needs to comb through. Finally, we see the coach announce that Pat will replace Alex on the relay team. After the team congratulates Pat, Alex hangs his head as the team walks away both disappointed because he will not be racing and with the knowledge that the coach picked Pat using fabricated data, even if Pat still deserved the spot.

The Message: What knowledge is embedded in the video?

We intended for the **data-driven** approach in the use of the Informonocle to push the viewer of their video to reflect on how being **data-informed** could be a better approach.

We also strived to convey three sub-points that could support a more data-informed approach. The first was showing how being too data-driven can limit a student-athlete's **agency** to make their own decisions. In the video Pat's teammates discuss how the use of the Informonocle would limit their ability to rest or decide to study when they needed to because the Informonocle would now track and report on their afternoon optional runs.[23]

[23] In the NCAA, coaches can only be present for up to 20 hours of practice time per week. In endurance sports like rowing and running, coaches might assign secondary workouts for the team to complete on their own without coach supervision. For myself in college we completed these in the afternoon, usually between 4-6pm.

The next point was showing how the result of limited autonomy could drive a student-athlete to **'cheat the system'** or use strategies of **obfuscation** such as lying or somehow producing fake data to manage how their coach views them. In the scenario, Pat wanted to reclaim his agency to make decisions that would protect his physical wellbeing. With the ability to produce fake data for his extra runs, he could avoid overtraining or burn out by getting rest when his body was telling him he needed it. However, Pat's character would never cheat in a competition or with performance enhancing drugs, so this decision to cheat also compromised Pat's value of **integrity** as an athlete.

And last, we intended this video to show how all the previous points could impact an athlete or coach's **mental health**. The "human moments" shown in the last few scenes where Pat tells his teammates about hacking the Informonocle, the coach struggles to make a decision, and Alex is frustrated after Pat is announced to the relay team were all intended to show the effect the Informonocle had on the team.

5.4.2. Video #2: Clippits

In this section I will describe the speculative technology in this video (Clippits), the scenario (what happens in the video), and the message that we wanted the video to convey which contains the embedded knowledge. **The Clippits video can be viewed here: https://bit.ly/clippits2.**

The Speculative Technology: What are Clippits?

Clippits are a set of clips athletes or teams can use to collect athletes biodata. Each clip is responsible for tracking one type of data, so the user can choose which data they want to track at a specific time. The types of data that Clippits can track are: Heart Rate, Steps, Calories, GPS, Pace, Sleep, and Blood Oxygen Saturation. Each clip can be attached to clothing or a provided elastic band.

Clippits can provide personalized insight that can be used to adjust an athlete's training and diet based on their body. Coaches can also use this data for more insight into their athlete's

performance—nothing needs to be a mystery anymore. Any data collected by the Clippits is available for the athlete or coach to view on an app on their phone or tablet, or on their computer in the browser.

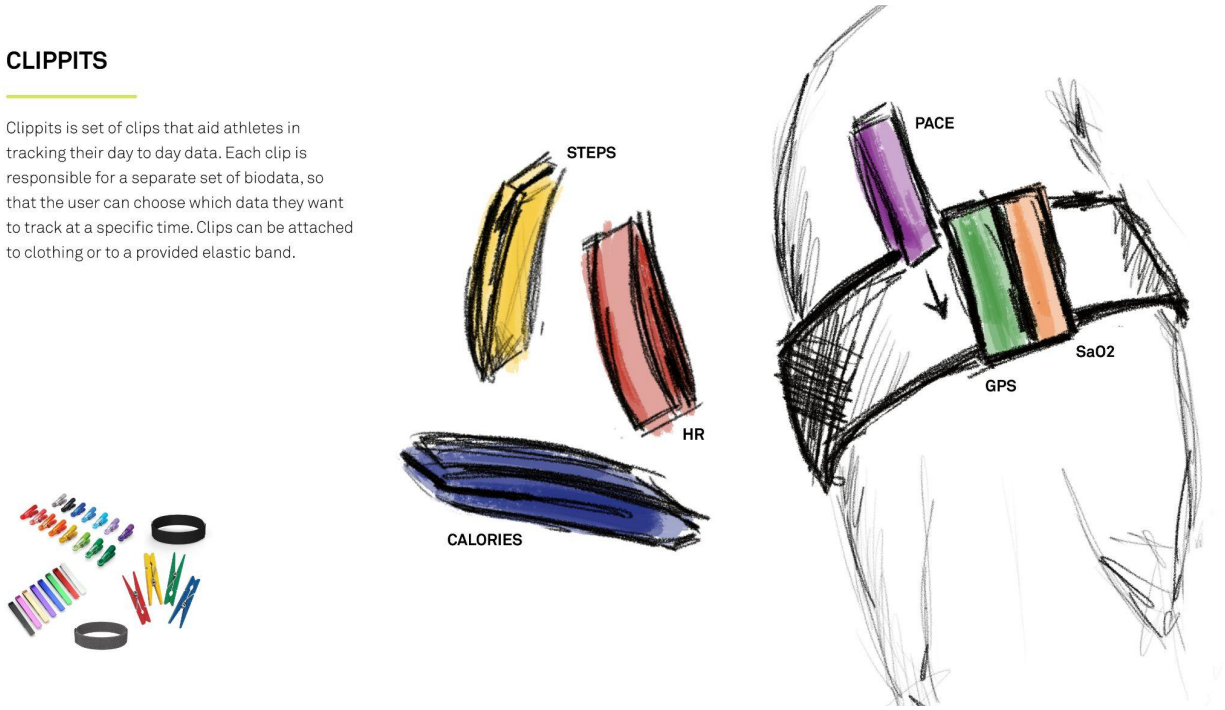


Figure 11. Sketch of the Clippits ideas taken from Team 2's presentation from the end of Quarter 1 and the design phase of the project. The team also included in the bottom left some inspirations for this idea including chip clips, hair clips, and clothes pins which were ultimately used to portray the Clippits in the video.

The Speculative Scenario: What happens in the video?

The Clippits video shows two similar scenarios played out side-by-side. Overall, the scenarios show a rowing student-athlete as she goes about her day in a future that is less than 5 years away. The two scenarios are shown using a split screen on the video so the left half shows an athlete with many Clippits while the right side shows an athlete with only one Clippit. Both athletes are acted by the same person to convey the idea that the only variable that is different is the amount of data being collected.

As the scenario progresses we see how the differences in the types of data that are collected affect the athletes when they wake up, at morning practice, at breakfast, during class, at afternoon practice, and at bedtime.

First in the morning the athlete with more Clippits is shown her sleep data and takes longer to get packed for practice as she checks the Clippit app on her phone and makes sure to pack all of her Clippits. Next at morning practice, the athlete with more Clippits and her teammate discuss how many meters they have to row in the morning because their workouts have been adjusted based on their Clippit data. On the other side, the athlete with one Clippit and her teammate both have the same distance to row. Then the athlete with more Clippits and her teammate need to attach all the Clippits to their armband before they start their workout while the athlete and her teammate with one Clippit each get started more quickly. To conclude this scene the athlete with more Clippits has more meters to row than her teammate so she is left to finish her additional distance on her own while the athlete with one Clippit and her teammate finish together and high five to celebrate being done. Overlaid on the screen during this scene is the data that the Clippits are tracking for each athlete. For the athlete with more Clippits there is more than one type of data shown while for the athlete with one Clippit only heart rate is shown.

In the next scene at breakfast the athlete with more Clippits has one Clippit that tracks calories so she is shown eating a breakfast that is within her calorie limit (shown on the screen) and when she reaches for a muffin she decides not to eat it. On the other side, the athlete with one Clippit is only tracking heart rate so she eats more for breakfast and decides to grab the additional muffin.

Next, the athletes are shown in class. The athlete with more Clippits is shown checking her Clippits data during class instead of paying attention while the athlete with one Clippit is shown taking notes.

The following scene shows the athletes at afternoon practice. Both athletes are taking a 2k test which is a 2,000 meter timed trial where the rower must finish as fast as they can. Again more data types are shown on the screen for the athlete with more Clippits while the other athlete has just heart rate. As the angle of the video changes we see the coach standing in the back watching. For the athlete with more Clippits, the coach is able to see more information about how the athlete is doing. The athlete with more

Clippits finishes with a personal best time and she attributes it to her Clippit data showing she was primed to perform well even though she was not feeling great. The athlete with one Clippit did not do as well and was not sure why because she felt good going into the test.

Finally, the athletes are shown getting ready for bed. The athlete with more Clippits takes all of them off while the other athlete rolls over and turns the light off. Then the athlete with more Clippits rolls over and turns the light off. As the screen goes black for the athlete with one Clippit showing that her day is over, the athlete with more Clippits rolls back over because she forgot to put on her sleep Clippit.

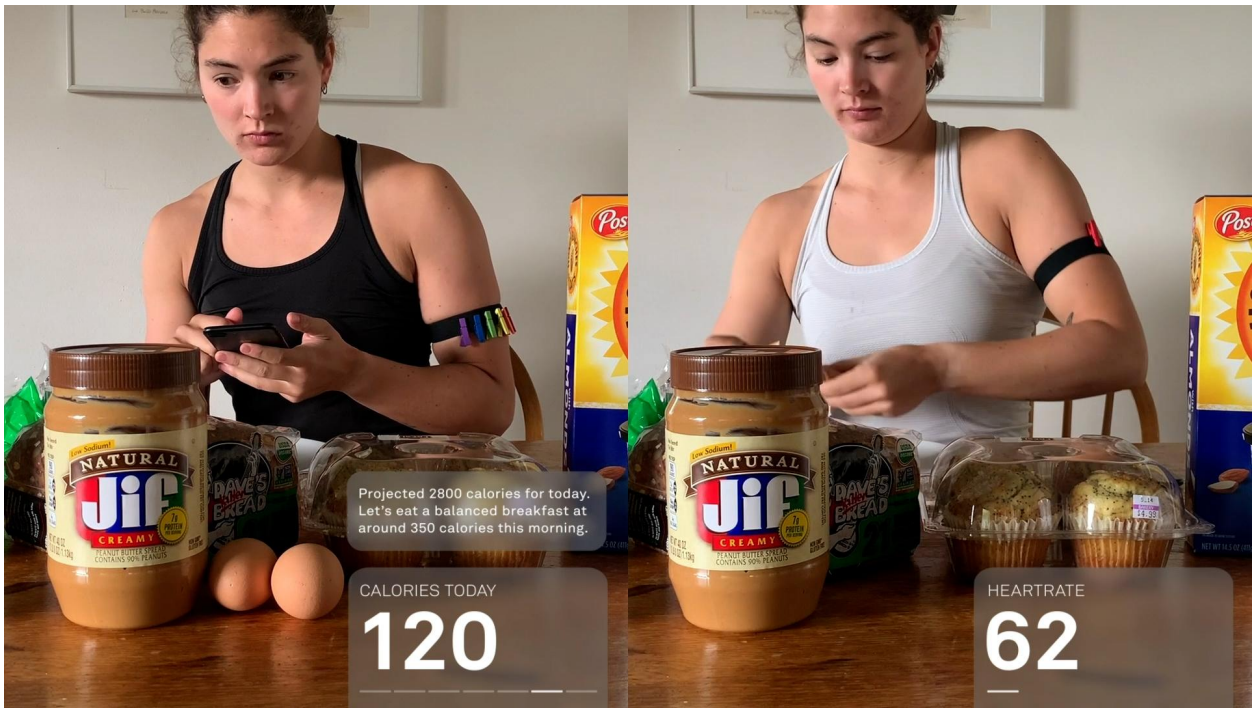


Figure 12. A still image from the breakfast scene in the Clippits video showing the split screen view. The student-athlete on the left in the black tank top is the one with more Clippits.

The Message: What knowledge is embedded in the video?

We intended this video to show the tension between **team and individual goals**. The goal was to push the viewer of their video to see how **using data to drive personalized training** might impact an individual and the team. We also aimed to show how coaches and/or athletes could use tracking data as a **tool for learning** and how this **knowledge (data) is power**.

For example, in the morning practice scene, Clippit data was used to personalize the workouts for the athletes wearing more Clippits. The personalized workouts support the individual performance and wellbeing of the athletes because the adjusted workout ensures that the athlete is not overtraining. This is in contrast to the athlete and her teammate with one Clippit who do the same workout together which is intended to represent prioritizing working together as a team rather than being treated as individuals.

Following this scene, all the interactions with the Clippits data shown in the scenario with the athlete who had more Clippits (more data) were intended to show how using data can be a tool for learning and how knowledge (data) is power.

Lastly, we aimed to show the possibility for **technology inequality** where some teams or individuals might have more access to technology than others. The possibility for technology inequality was embedded into the structure of the video and the scenario showing one athlete with more Clippits than the other. This was analogous to how some teams in the NCAA may be able to afford more technology than other teams that have basic heart rate monitors.

However, as the video developed, the differing amount of Clippits led us to ask the question: **How much is too much (data)?** We were unsure of whether a preferred future should include more or less data, but this video could start that conversation. This message came through because the goal of the Clippits was to show in a literal way how much data was being collected. Having seven Clippits compared to one Clippit visually reinforced the message. The team of students working on this video even considered having the athlete with more Clippits appear weighed down on one side by the Clippits to further convey the physical and emotional "weight" of collecting so much data.

5.4.3. Video #3: EnVisible

In this section I will describe the speculative technology in this video (EnVisible), the scenario (what happens in the video), and the message that we wanted the video to convey which contains the embedded knowledge. **The EnVisible video can be viewed here: https://bit.ly/envisible3**.

The Speculative Technology: What is EnVisible?

EnVisible is a team performance tracking system that helps athletes and coaches monitor performance and recovery. Athletes are equipped with a data visualizer and voice operated system that helps them see their own data and compare it to their teammates. Through this system they are also able to control who their data is shared with and what data streams will be shared automatically or not. Coaches have a similar set up for viewing any data the athletes choose to share. Both athletes and coaches also have one or more small round devices that are able to collect and transmit various types of data. If an athlete is sharing their tracking data with the team, the device will have a green indicator light on.

The elements of the EnVisible tracking system were designed with visibility in mind and different ways to make the idea of data visibility more tangible. For example, the visualizer is always on keeping the athletes own data and their teammates visible and the indicator light is a visual representation of whether or not the athlete's data is visible to others.[24]

[24] Please note that we were not able to incorporate the green indicator light into the video. Though the prop lights up, this was not visible on camera and we lacked the video editing skills to add the light as a visual effect.

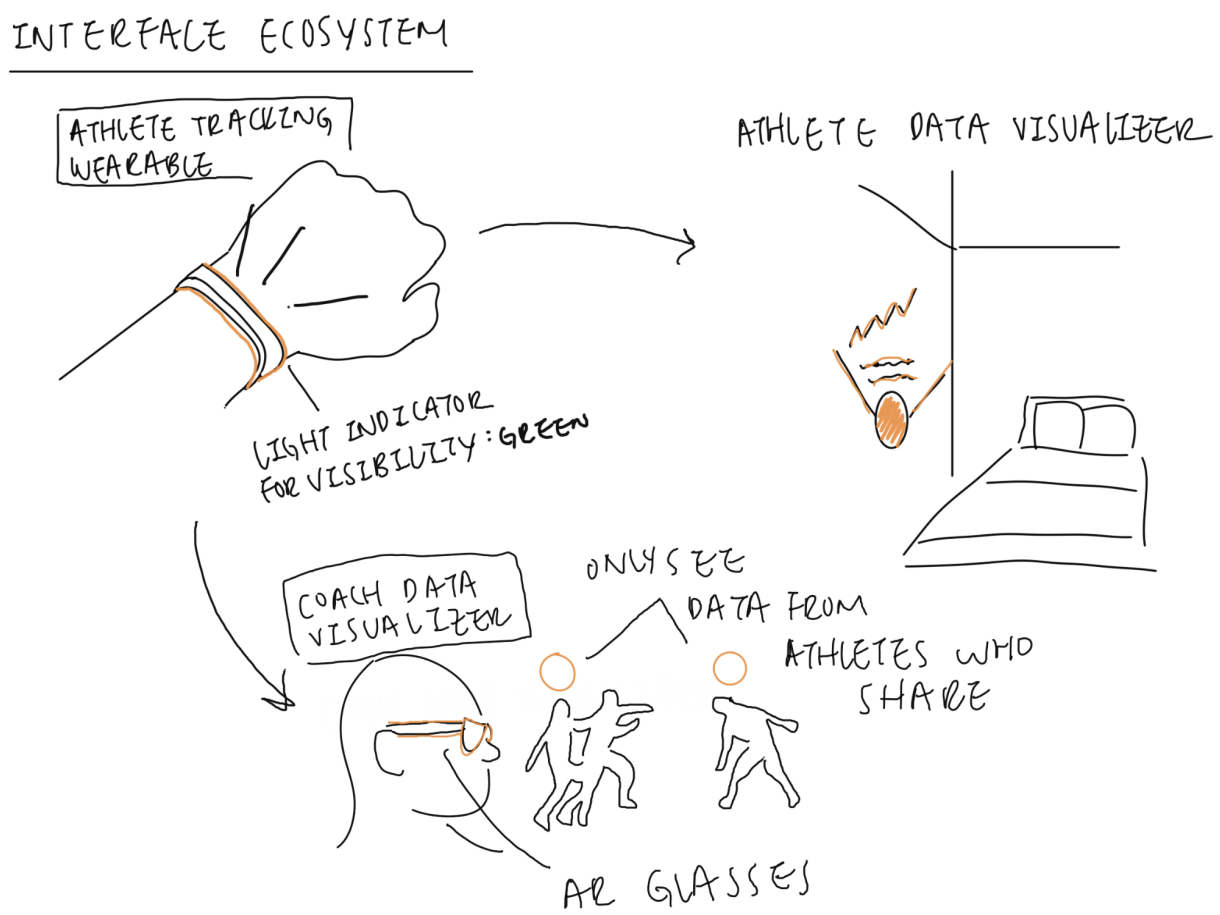


Figure 13. Sketch showing the EnVisible product ecosystem. This sketch was created during the design process and is not consistent with the final video prototype.

The Speculative Scenario: What happens in the video?

The scenario for this video begins with a basketball student-athlete, Anne, getting ready for bed. Anne takes off her EnVisible tracker and places it on the charger that sends her data on the data visualizer which is projected on the wall behind her bed. She notices that she needs to get some more sleep, especially in comparison with her teammates who are getting more sleep. As Anne gets in bed she notices a recent test she took where she got a bad grade. She decides to stay up to study more so she can do better on the next test. Anne finally goes to bed around 3:00am (the time is projected on the data visualizer above her bed).

The next scene begins at 7:00am as her alarm is going off. The alarm stops when she says “I’m up.” This voice interaction and the visualizer are meant to be early indicators to the viewer that this

scenario takes place in a future that is at least 5-10 years away. Anne places her EnVisible tracker on the charger again and her data is projected on the wall showing she only got 4 hours of sleep. The EnVisible system asks her if she wants to share her sleep data with her coach. Given that she only got 4 hours of sleep, Anne responds “definitely not” and the system responds “Automatic data sharing is off.”

Next, Anne is discussing the EnVisible tracking system with her teammates. Her teammates have their data sharing on and are complaining about their coach seeing their data. Anne reminds them that data sharing is optional. Anne’s teammates feel peer pressure to have their data sharing on. They also discuss not having enough time to study because they need to get enough sleep so that their coach does not bench them for the game. The scene ends with everyone laughing in response to Anne’s question, “Why don’t you just not share your sleep data?” The implication of this question and the laughter is that not sharing your sleep data is an equivalent of telling the coach you did not get enough sleep.

The following scene shows the coach addressing Anne and her teammates. The coach makes a point of telling the team why she wants to collect data and reminds them that data sharing is optional and they will not be penalized for not sharing. At the end of the scene Anne is announced as a starter for the game tonight in place of another teammate who is sitting out due to an injury.

The team loses the game and the next day the coach gathers the team to review footage of the game to learn from it and improve. Before the film session starts two members of the team are having a whispered conversation. One teammate is frustrated by those who are not sharing their data while the other is okay with it saying that she would have turned off sharing except she hopes that the data will prove to their coach that she deserves a starting spot. The coach also asks Anne to stay back after their film review.

After the film review sesion Anne and the coach have a conversation. The coach is concerned about Anne because her performance in the game was lacking compared to what the coach knew she was capable of from practice. Anne says she must have just had a rough game. Though the coach is coming

from a place of concern and wanting to help Anne improve, she implies that Anne was responsible for a lot of turnovers because she was not in position and suggests that if Anne turned on her EnVisible data then the coach could help her figure out what was going wrong. However, the coach does not want her to feel pressure and reminds her that it is optional to share her data. Anne says she will think about it.

In the final scene we see Anne tossing and turning while trying to sleep representing her inner turmoil. Then we see her the next morning twiddling her thumbs trying to decide whether or not to turn on the EnVisible automatic data sharing. The video concludes as she turns on data sharing and EnVisible responds, “Thank you for sharing your data.”

The Message: What knowledge is embedded in the video?

Our goal for this video was to convey the tensions between **privacy, trust and accountability.** The competing perspectives within these tensions were athletes' individual need for privacy to be able to make their own decisions to prioritize different elements of their lives—athletics, academics, wellbeing, and socializing—and the team values of trust and accountability. The example shown in the video is the athletes' need for keeping her sleep data private as she compromised her sleep to study for a midterm. Implied by the video is the athletes’ fear of repercussions such as being benched should her coach know how little she has slept. By not sharing her data she is compromising her coach and teammates' trust and their ability to hold her accountable. Additionally, as the team’s success is dependent on everyone’s ability to perform well, her coach made a decision to name her as a starter for the game without the information that her performance *might* be compromised by her lack of sleep.

We intended for the viewer to raise these questions about their preferred futures: **Should team success or individual autonomy be prioritized? Do athletes have a choice to share their data?**

The prompt for the question was made overt through the focus on a theme from the iteration phase of video design: **data visibility**. Data visibility refers to who is able to access data from a tracking

technology and how the data is shared with others who have access to the data. Though we also aimed to think of data visibility more literally in how data might be made visible to an entire team in real time or how the coach or team could know whether one athlete was sharing their data or not, these ideas did not make it into the video.

Figure 14. Still image from Video #3: EnVisible. The main character, Anne, stands in her bedroom answering the question from EnVisible, "Would you like to share your sleep data with coach Lydia?"

In this video, the research team decided to use the example of sleep data because it is an example that can convey the tension between privacy and agency versus sharing a data stream that is important to athletic performance. This choice resulted in the repeated use of sleep as an example due and sleep data becoming almost synonymous with the message of this video that is further unpacked in the next chapter. However, there are other data streams, including ones collected during an athletic performance (e.g., concussion data, continuous heart rate, location) that athletes might also prefer to keep private or need agency to choose not to share.

5.5. Summary: Knowledge Embedded in the Videos

As Research through Design and Discursive Design artifacts, the videos embed knowledge about preferred futures and not preferred futures for the design and use of tracking technologies. Therefore, the videos themselves are a contribution to the research question and my dissertation aims.

Table 6 summarizes the knowledge embedded across all three videos about preferred and not preferred futures for the design of sports tracking technology and its use by college sports teams. The videos also include knowledge about significant uncertainties that the research team had that we believed need to be discussed and addressed in the future design and use of sports tracking technologies.

Preferred Futures	● A data-informed approach emphasizing balance and prioritizing decisions supporting athlete physical and mental wellbeing over data. ● Using data for personalized insights about training, creating individualized training plans, and as a tool for athletes to learn about themselves. ● Athletes having control over their data and deciding whether or not to share it with their coach, teammates, or other roles. ● Trust and accountability supported in the design and use of tracking technology.
Not Preferred Futures	● Reinforcing a coaches power over student-athletes through extraction and coaches unfettered access to student-athlete data. ● Distrust created by student-athletes choosing not to share data with a coach, teammates, or others. ● A data-driven approach limiting student-athletes' agency to make their own decisions to prioritize academics or physical and mental wellbeing.

	• Surveillance of and a lack of agency for athletes impacting a student-athlete's mental health and leading an athlete to 'cheat the system' or use strategies of obfuscation, such as lying or somehow producing false data, to manage how others perceive them. • Production of false data because it takes energy from student-athletes and the use of false information by coaches could be harmful. • Technology inequity where some teams or individuals have more access to technology than others.
Uncertain Futures for Discussion	• How much data should be collected? How much data is too much to collect? • How to prioritize, or compromise on, team success or individual agency. • How to provide athletes agency in sharing their data.

Table 6. A summary of the knowledge embedded in the videos.

CHAPTER 6

Speculating the Futures of Sports Technology (Study 2b, Preferred Futures)

The previous chapter described the first part of this study where a group of students and I created speculative videos that were designed to spark reflection and discussion about the design and use of sports tracking technologies. This chapter will describe the second part of the study where preferred futures for the design and use of tracking technology were identified through analyzing reactions to the videos.

6.1. Methods for Collecting and Analyzing Reactions to the Video Prototypes

This section will describe methods used for evaluating the speculative videos with members of the college athletics community, conducted from Fall 2021 through February 2022.

6.1.1. Audience interaction with artifacts, designers

The previous chapter discussed how discursive designers do not often evaluate their designs. I wanted to know what value or impact the videos produced for this study have, if any, to the intended audience and if each video is able to create the discourse the designers, my research group and I, intended. Therefore, I approached evaluating the interaction with the artifacts with two methods:

Organic Interactions. At the conclusion of the Spring 2021 quarter, I uploaded the videos to YouTube and embedded them in a website with supporting information describing the design process and including artifacts from the design process. Figure 15 shows a screenshot of the website I created to display and distribute the videos and supporting materials (*explanatory artifacts*).

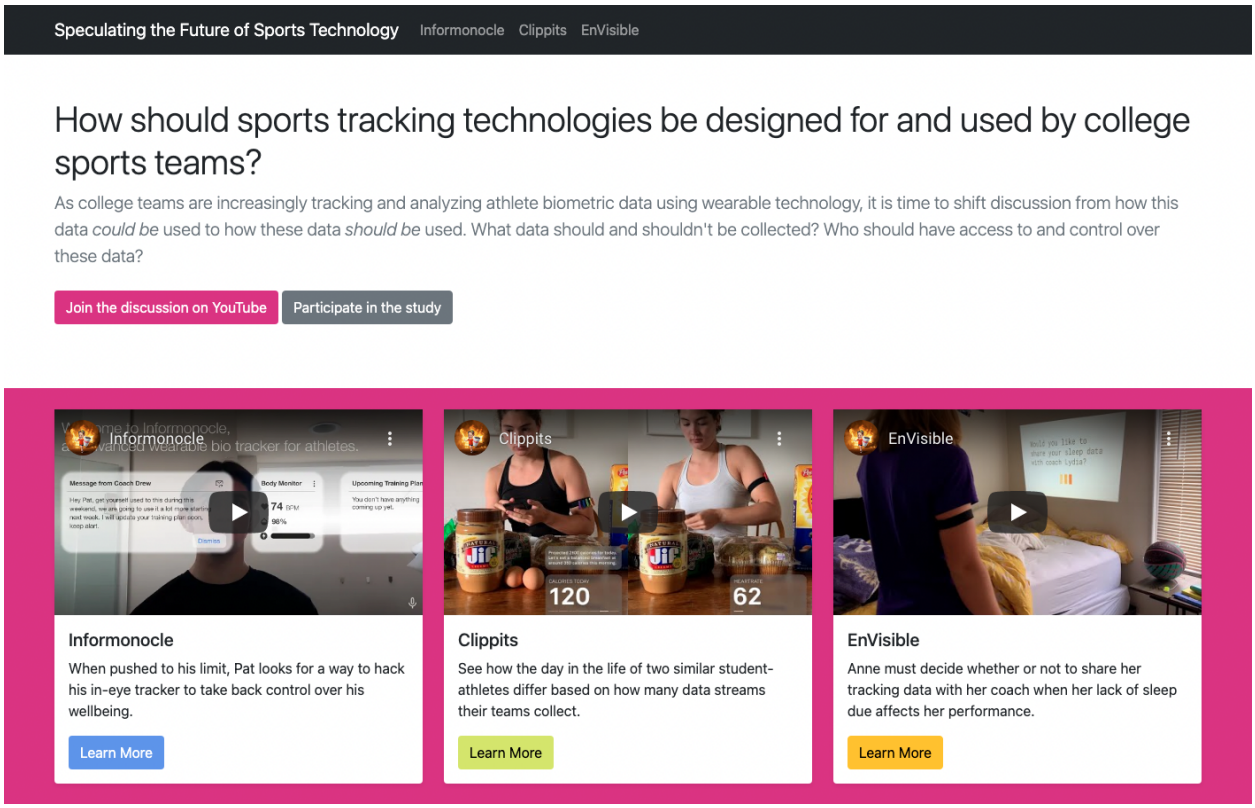


Figure 15. Screenshot from the study website: https://kolovsam.com/speculating-future-sports-tech/.

I then shared the videos on Twitter, Facebook, LinkedIn, Instagram, and Reddit and encouraged the rest of the research team to do the same. I also set up bit.ly links for each video, the website, the study participation information sheet, and the survey to recruit participants. Using these links, I would know how many people clicked on each link in addition to seeing how many times the videos were watched on YouTube.

This method of distributing the videos and attempting to generate reactions was not successful. Given that this method did not contribute to the discourse around preferred futures for tracking technology, further elaboration on this method can be found in Appendix III. Though this method was unsuccessful for generating reactions, posting the videos online played a role in recruiting participants for the interviews and small group discussions.

Interviews & Small Group Discussions. Interviews and small group discussions with student-athletes, coaches, and designers were used to collect reactions to the videos. The sessions were conducted, transcribed, and analyzed by myself, Sam So (HCDE PhD student), Akshay Rawat (HCDE Master's Student), Nisha Jain (HCDE Master's Student), and Roz Gille (HCDE undergraduate student). Almost every session had a secondary interviewer to assist with note taking, asking follow up questions, and managing the session.

During the sessions, each participant watched and discussed two videos. Following introductory statements and obtaining consent to record (5-10 minutes), the format was: watch one of the videos (4-6 minutes), then discuss the video (15 minutes), watch a second video (4-6 minutes), then discuss the second video (15 minutes). One-on-one interview sessions lasted 60 minutes, except A1 whose session was 90 minutes as she volunteered to watch the third video. Small group discussions lasted 75 minutes to account for the extra time needed for participants to record their individual reactions to the videos before we started discussing the videos where their initial reaction might have been changed by the other participant(s).

The videos for each session were chosen at random or to ensure that all three videos were being watched an even number of times. Video #1: Informonocle and Video #3: EnVisible were viewed by 10 of the 15 participants. Video #2: Clippits was viewed by 8 of the 15 participants.

For the discussion portions of each session participants were encouraged to treat the video like a prompt. All participants were asked the same first question: *What is your first reaction to the video you just watched?*

Following this question, I had prepared a list of follow up questions that were divided into two categories. The first were questions aimed at pushing the participant to talk more about their reaction to the video:

- Was there anything that surprised you?

- Did anything make you uncomfortable?
- What did you like/dislike?
- What does the video make you think about wearable/tracking technology?
- If we looked out 10 years from now and this was a reality...how would you feel about that?
- What kind of concerns do you think people would raise about this?

The next set of questions was curated for directly asking the participant questions posed by the video they watched, but we never used this set of questions.

The purpose of structuring the discussion sessions this way was to see if the videos themselves were effective in sparking reflection and discussion or whether we needed to push the participants to keep talking with more questions. I also wanted to know if the videos would be effective in generating discussion around the message we intended for each video without asking a direct question. Therefore, not needing the last set of questions is both an indication that the videos sparked enough reflection or discussion to last 15 minutes and that the participants discussed what we intended the videos to push them to discuss.

We also found that we needed even less of our questions if we asked participants to explain what they meant by some of their reactions.

Each participant was compensated with a $30 Tango gift card.

6.1.2. Analysis

Data collection began in Fall 2021 and continued through February 2022. Each session was recorded on Zoom and afterwards the research team and I were able to edit the Zoom transcript produced by Otter.ai to produce a cleaned transcript. Then each transcript was coded using a code book developed by Sam So and myself prior to starting data collection.

Developing the code book

Sam and I developed the code book to address some of the questions we had for the study. First, we wanted to know if the videos were effective in sparking discussion around the message intended for each video or whether what the participant was related to another video or related but not intended.

If what the participant was saying related to the intended message for the video they were reacting to, we added a code for the intended theme that they were discussing. For example, if the participant was watching Video #1 and talking about something related to the message for Video #1, we coded it as related to Video #1. Our codes also included some information that would help us understand what about the participants' statement was related to that video. For example, a key part of the message for Video #1 was the tension of *data-driven versus data-informed.* If the participants statement was related to that tension it was coded: *Video 1: data-driven versus data-informed*.

Also, if the participant was discussing something related to the intended message of a different video, we coded it as related to that video instead, or if the statement was relevant to the research question but not to a specific video, it was coded as *related but not intended*.

In addition to codes for the messages embedded in the videos we had predetermined codes for *preferred design* and *preferred use*. These were specially aimed at identifying reactions that indicated a participants preferred future for the design or use of sports tracking technology.

Coding

However, we did not expect all the reactions, reflections, or discussions to be what was intended in the design of the videos and wanted to leave room for emerging themes. As Sam and I tested the code book and aligned our codes for the first five sessions, we added codes that reflected themes we constructed based on how participants described their preferred futures.

After the first five sessions, more members of the research team were added to help with the analysis. This group aligned on our understanding of the codes again and as the remaining sessions were transcribed and coded we wrote memos about the emerging themes and connections we were seeing across multiple codes or reactions across all three videos.

Affinity analysis

Once we had data from 10 participants, I started to get the transcripts ready for analysis on a Miro board. I double checked the coding on each transcript, downloaded a PDF, extracted each page of the PDF as a JPG, uploaded the images to Miro, and finally cropped the images so that each coded section of transcript could be moved around the virtual board.

We started by grouping all data with the same code and doing an affinity diagram within that code. This included analyzing any reactions that discussed an intended topic for a video but not analyzing all the reactions separately by video.

Following this initial analysis we started to look across codes and focused on identifying preferred futures to answer the research question. The preferred futures will be discussed in Sections 6.2-6.5.

6.1.3. Participants

We had 15 total participants in the study: 4 student-athletes, 5 current or former athletics staff, and 6 designers. Half of the participants were recruited through the survey distributed online and the other half were recruited through my personal connections or personal connections of the research team. One participant who was recruited through the survey, S5, Though the videos were posted online and some of the participants were recruited that way, only S5 watched one of the videos prior to participating in an interview.

I reached out to participants who responded to the recruitment survey that had a diversity of sports and roles and I sought to have at least one group session per stakeholder type (student-athlete, staff, and designer). I also recruited participants through personal connections to reach stakeholders that the survey did not reach.

Session	**ID**	**Role in relation to the study**	**Age**	**Gender**
Individual Interview	A1	Nordic skiing student-athlete	18-25	Woman
Group Interview	A2	Football student-athlete	18-25	Man
	A3	Esports student-athlete	18-25	Man
Individual Interview	A4	Track & Field student-athlete	18-25	Woman
Individual Interview	S1	Women's Basketball Coach	45-54	Woman
Group Interview	S2	Former university athletics staff	35-44	Man
	S3	Former university athletics staff	35-44	Man
Individual Interview	S4	Women's Rowing Coach	35-44	Man
Individual Interview	S5	Women's Volleyball Technical Coordinator	26-34	Man
Group Interview	D1	Designer for digital health platform and former student-athlete	26-34	Woman
	D2	Designer and former student-athlete	26-34	Woman
Individual Interview	D3	Designer for large fitness company and former student-athlete	26-34	Woman
Group Interview	D4	Former industrial designer, current human centered design student	26-34	Man
	D5	Former Samsung wearables designer	26-34	Woman
	D6	Former Samsung wearables designer	26-34	Man

Table 7. Information for participants in the video reaction sessions. The participant IDs refer to student-athletes (A), staff (S), and designers (D). Those listed in adjacent rows colored grey participated in the same session together.

In the sections that follow, the participant IDs will be used to refer to a reaction made by one of these participants. For example, if S4 is quoted, their statement will appear in quotes and/or italics followed by the ID in parentheses like: (S4).

6.2. Preferred Futures for the Design and Use of Sports Tracking Technologies

The premise of my dissertation is to shift the conversation from how sports tracking technologies *could be* designed and used to how they *should be* designed and used.

As I found in Study 1, it is difficult to support individual and team goals in the use of the tracking technology and data as it is currently designed, so the conversation needs to shift. The videos we produced in Study 2a (Chapter 6) were effective in directing the conversation onto what tensions need to be considered when adopting a new technology and what should be avoided when using sports technology and data in team sports.

The video prototypes each presented a preferred future that was intended to incite reflection and discussion about what preferred futures student-athletes, coaches, and designers want, so this study could answer the question: *What are the college athletic community's preferred futures for the design and use of tracking technology?*

In the three sections that follow, Section 6.3-6.5, I describe the preferred futures synthesized from the reactions to the video prototypes. These three sections follow three major areas for preferred futures for the design and use of sports tracking technologies, identified through analyzing reactions to the videos:

1. **Preferred futures for data interpretation and use (Section 6.3):** The reactions to the videos suggest preferred futures for tracking data interpretation and use that take a holistic approach to data collection and use, augment and not replace human expertise, and focus on personalizing

insights and trends in the data. These preferred futures were the most straightforward and improved design and more education or expectation setting around data use could make these preferred futures a reality.

2. **Preferred futures for tracking data management (Section 6.4):** The reactions to the videos suggest that student-athletes want privacy and agency to have control over their data, but this is in conflict with both student-athletes and coaches' needs for sharing data. One preferred way to address this conflict was giving student-athletes the option to share their data, however, something that is optional can become coerced due to power dynamics between coaches and student-athletes. Significant changes will be required to balance the needs of student-athletes and coaches such as considering appropriate flow of information in the design of tracking technologies and supporting open communication in the use of tracking technologies.

3. **Preferred futures for supporting student-athlete mental health (Section 6.5):** The reactions to the videos suggest that supporting student-athletes' mental health in relation to tracking data needs to be part of preferred futures for the design and use of tracking data. In addition to the pressure that student-athletes are already under to perform well academically and athletically, tracking data poses concerns for athletes mental health and overall wellbeing. The reactions to the videos describe how tracking data can increase a student-athlete's anxiety and feelings of falling short and how to reduce this harm through the design and use of tracking technologies.

6.3. Preferred futures for data interpretation and use

The preferred futures for tracking data interpretation and use include taking a holistic approach to data collection and use, augmenting and not replacing human expertise, and focusing on personalizing insights from data and trends in the data.

6.3.1. Taking a holistic approach to design and use of data technologies

The message that the design and use of tracking technologies should incorporate a holistic approach was not precisely what was intended by any of the videos. However, this preferred future could be in response to the data-driven approach portrayed in Video #1: Informonocle or elements of the other videos where data was given more value than the human experience. Overall, the participant's reactions discussed how **data are not holistic** and argued for taking a more holistic approach to the design and use of tracking technologies and data that gives equal value or more value on human experience or expertise over tracking data.

Taking a holistic approach means treating athletes as humans first

The preferred future of a holistic approach starts with viewing athletes as humans first and includes collecting subjective data and accounting for context.

Several participants pointed out how tracking data on its own reduces athletes to something less than human: "*I think it turns people into robots versus humans and athletes"* (A1 in reaction Clippits), "*Everyone involved is not just a data point, they're a human being with feelings"* (D3 in reaction to Clippits), "*...the coach is looking at the athlete, not as human, but data*" (D4 in reaction to Informonocle).

As A1 reflects, this may be because "*[the data] fails again to take into account discrepancies in the day that are just gonna like...stuff happens that isn't totally structured and planned"* (A1 in reaction Clippits). Human life has moments that cannot be accounted for by technology.

In the videos, similar to current tracking data, there was only physiological data (e.g., heart rate) or sport specific stats (e.g., speed, number of points scored) represented. However, these data did not account for other emotional, mental, situational, or unquantifiable factors that are part of being human.

D4 remarked specifically about how mental or emotional factors were not considered at all in the scenario they watched:

> *"[The video is] focused mainly on the physiological parameters, which is not all there is to, you know, progress in life, there are emotional and mental parameters also that are not recorded that inform your performance and progress overall which were not taken into consideration—in fact these were kind of being encroached upon by the scenario in which there were so many sensors*" (D4 in reaction to Clippits).

A2 and A3 also described how sports have an unquantifiable aspect to them like the "*flow or the game*" (A2), "*the opportunities a team sees together*" (A3), and D2 argued that: "*Sports aren't played on paper. There's so many more factors than just however many points someone scores or however many wins the team has*" (D2 in reaction to EnVisible).

If data cannot account for emotional, mental, situational, or other unquantifiable factors of human life or sports, then designers and teams must find a way to consider these factors so that the design and use of tracking data is more holistic. For example D2 suggests that coaches, other staff, the technology, or even the athlete themselves needs to pivot away from reactions like "*your sleep is bad, makes you bad*" (D2 in reaction to EnVisible). D2 made a suggestion for a preferred approach:

> "*It's that they cared more about you and your numbers, even just in terms of your playing numbers, instead of you as a person. Like if you're not getting enough sleep: So what if you're only getting four hours of sleep? What's the reason for that? And they have to know the human to know the reasoning for that instead of just saying like 'oh it's going to negatively impact your performance'—make it better*" (D2 in reaction to EnVisible)

As D2 suggests here, rather than looking at only getting four hours of sleep and how that could impact performance as the problem, step back and look at the situation holistically. Maybe the student-athlete had to stay up and study for a test or maybe they are having trouble sleeping due to stress. These are human

problems and the data point, ‘four hours of sleep’, does not represent these problems. Identifying the human problems opens the door for supporting the student-athlete in managing aspects of their life that are impacting their sleep.

D2's suggestion also implies the importance of coaches or other staff just having a conversation with athletes either about their data or how they can support them. D1 adds an interesting thought about a scene in the video that portrays the coach as wanting more data to inform her about the athletes performance rather than just relying on a good conversation with the athlete:

> *And then it's also interesting how it seems like it's around the clock monitoring. Like in the comment, the coach was like “you weren't in the right position during the game”. Which makes sense when you're doing video review or you’re wearing that tracker during the game. And it seems like they almost wanted more tracking and fine grained data of what's happening outside of the game to inform more of why she wasn't in the right positions... It's like that kind of need to have data to make sense of things, rather than just leveling with the person and talk to them like a human.* (D1 in reaction to EnVisible)

Therefore, part of a holistic approach would include positive, trusting relationships that are built between athletes and coaches (and staff). Data cannot account for everything and is not representative of the athlete so the coach and staff must know the athletes as people first.

S5 also agrees with this approach and acknowledges that there is so much that is valuable that is out of the coach's control, so there it no good replacement for a conversation:

> *And that's, [how to drive value out of tracking technology] is only a part of it. The other part which might be even more valuable is the stuff that we can't control. The coaching staff always wants to control for better or for worse, they think for good, and my hope is for good. Right? But are [the athletes] eating well and sleeping well? Are they stressed*

> *out? I don't think there's a good replacement for just checking in with your athletes regularly. But sometimes technology can help with that* (S5).

Designing for a holistic approach using subjective and contextualized information

In addition to the approach taken by a team to be holistic, the design of the technology can also support a holistic approach. As previously mentioned, the data represented in the videos is only physiological which is consistent with most current tracking technologies. However, there are ways to design for collecting subjective data.

A good example of this in current technologies is a feature of Whoop called the Whoop Journal. A1 described the Whoop Journal:

> *So I feel like implementing kind of like a daily check in like I open the Whoop app and I just click a couple of buttons like did you sleep in the same bed, did you listen to white noise...it has a marker that's like rate how your emotions are today like da da da, and that incorporates things for women like menstrual cycles, sickness, if you're caregiving. Just like a more holistic view, I think it is super important* (A1 in reaction to Informonocle).

There are many options for subjective data to track in the Whoop Journal including whether or not you used a phone before bed, if you drank caffeine, if you took vitamin D, how you felt your energy level was throughout the day, if you stretched (or did other recovery activities), if you drank alcohol, and many more. These represent both objective and subjective information that can only (currently) be tracked through self-reporting, and these data could provide additional contextual insight about what is going on with an athlete's body.

For A1, she was only using Whoop on her own. As I will describe in Section 6.4, athletes might not want to share information about their personal life with their coaches or other staff members and the

information that the Whoop Journal can track might be very personal. However, tracking technology could support a similar design and integrated approach for tracking measures that athletes already share such as those from the Wellness Survey described in Study 1. Integrating the athlete self-reported measures (ASRM) such as soreness and rate of perceived exertion with heart rate, and other tracking data could add more human context to the tracking data.

Contextualization also supports a holistic approach because it could help coaches build empathy with athletes as humans and not as their data. For instance, D2 discusses a hypothetical scenario of how a "*really crappy 5k*" performance by a student-athlete may appear differently in a silo than when you take into account the "*30k the athlete has already run that week*."

6.3.2. Using data to augment and not replace human expertise

> *I think it's important with all of this technology that it's to better and not replace. Because at this rate, we would just be watching robots play sports. And you know, taking the human factor out of it completely, but that's why we love sports: it's the human story. I mean who doesn't love the underdog story? Why do we love so many sports movies? And, you know, why are all of these athletes so renowned and famous in the world?* (D2)

Similar to the arguments made in the previous section, D2 emphasizes a preferred future where tracking data are used to augment and not replace the human experience because, as D2 describes, "the human story" is what makes sports compelling.

This statement and this section present evidence that participants were in agreement with the message presented in Video #1 that taking a data-informed approach is preferred over a data-driven approach in the design and use of tracking data.

Augment the expertise or intuition of a coach with data

A coach is a coach because they have specialized knowledge about their sport and are skilled at helping athletes and teams reach their potential. As D3 puts it, "*the best place for team wearables to fit in*" is to support the coach's intuition and explain athlete behavior and performance.

For instance, after watching the Informonocle video, D3 commented on the on-field observational capabilities of a coach and claimed how data could "reinforce or explain why that's happening" and compliment the "visual part" of their job:

> *So like, coaches, I guess, to put it generically, they're like, really good at watching the athlete. They're like, they can watch someone run like the coach in the example, he watched his runners, and he said, your knees are a little bit wobbly. Like he's good at his job, because he notices that stuff on the field. So if the data can just reinforce that or explain why that's happening to the coach, he's already doing that job of doing the visual part.*

When prompted to give more detail on how the technology could support the coach in this instance, D3 continued:

> *Yes, I think we'll use the example of like, the coach sees a runner with a wobble. But maybe that runner is wearing some sort of tracker. So maybe the tracker has like a built in whatever smart system that tells the coach that this athlete is overtraining or is putting way too much pressure on their left leg versus their right leg, or maybe their smart shoes, and they say this runner spends too much time on their toes, not enough time on their heels when they're running or something. So that way, the coach doesn't have to go look at a spreadsheet or whatever, and interpret that themselves. The coach notices something- a wobbly knee- and the data tells them, like, too much time on the foot and then the coach*

is able to make that connection. And then, you know, use their expertise to train around that.

Inform coach decisions and strategy with data

Tracking data can also provide information that the coach cannot get otherwise from their skills of observation or can provide more information that could make difficult decisions a bit easier to make. For example, S1 described how she, with the help of her strength and conditioning coach, uses tracking data to inform her decisions about what her athletes will doing during practice:

> *Our performance coach has you know the Catapult information it all goes to him and then he gives me data after each practice that shows what load each player hit like what we wanted the goal to be and where they were actually and then he gives me a brief like written kind of summary of you know, she's at her goal, I think she could use, you know, a steady practice. And she was way below, I think she needs some conditioning after practice, she was way over, I think she should take more reps off, then I use that in formulating a practice plan.* (S1)

When prompted to expand on what exactly she would change for practice, S1 continued:

> *So yeah there's extensive work and intensive work...our performance coach has drills labeled or tagged in one of those two categories and so he'll say to me, based on the load and the numbers of what we've been doing, you need a day that's more intensive or you need a day that's more like this, so I pull from those drills because he's told me these drills are good on this type of day, maybe I have two transition drills right, one works their bodies in one way, the other one works their bodies in another way, and based on what their bodies need I choose a certain drill* (S1).

In this example, load refers to training load which is a measure of how much stress or strain an athlete's body is under. As S1 describes, she can use load to determine what kind of work will be best for her athlete's body for a given practice. Load is a measure that is calculated based on the athlete's heart rate so S1 could not determine her athlete's load through observation, athlete self-report, or any other way. She could perhaps observe or talk to the athletes to gauge their level of exhaustion, but a student-athlete is likely exhausted most of the time, so this would not be as reliable for figuring out when is a good time to do more or less intense work.

Informing strategy is another area where data could help inform a coach's decisions. None of the participants described having used data for this purpose. However, D1 and D2 noted the opportunity to use data to "*inform better strategy*" (D1). If "*coaches spend hours pouring over game footage*" (D2) looking for some advantage they could use, then there is an opportunity to help coaches in their analysis. Understanding what information would be helpful in augmenting a coach's expertise would require further research that focuses on video analysis that could help coaches analyze video more quickly or what data specifically could help coaches confirm their observations about team strategy.

6.3.3. Tracking technology should be designed for personalized insights and used for individualized decisions about training

Using data to individualize or personalize training for athletes on a team and empowering athletes with their own data as a tool for learning was part of a preferred future embedded in Video #2: Clippits. Participant's agreed that this is a preferred future.

A1, S4, D1, and D5 all made remarks about individualization or personalization being a preferred goal for the design and use of tracking technology. These remarks align with the understanding embedded in Video #2 that individualization or personalization refers to an individual athlete's body or performance. Coaches do not have time to create an individualized experience for their athletes (See Study 1), so

technology could help fill in that gap. S4 described how he saw hints of his preferred future for wearable technology in the videos, but he felt it was not individualized enough:

> *I think one of the shortcomings of wearable tech right now is that it's very generic, it's painted with a broad brush because that's probably what's profitable...I think that was presented in the two videos like they started to get into individualizing it which I think can be useful. But I think that could go a little bit further...it's one of those things where for it to be most useful and most productive for an athlete and a coach it has to be really highly individualized and I think that's sort of where the videos were starting to head* (S4 in reaction to EnVisible)

D1 agreed that the current technology is too general, but had a slightly different view on personalization that what we had intended to show as a preferred future in Video #2 as she suggested a focus on groups of users or sports and designing for specific use cases:

> *So I think it goes back to you don't really know that end user. So you're throwing this very general technology at a ton of different use cases and kind of hoping it lands somewhere? And I think by hoping it lands somewhere it misses the mark on almost every single one. Because it's like a catch all design, rather than saying, "Okay, what would be really useful for sprinters?" or something like that* (D1 in reaction to Informonocle).

Similar to D1's suggestion for focusing on user groups, D5 described the value in focusing on user groups in design. In D5's previous job designing wearable technology with a global user base, figuring out what information would be useful in the design was challenging until she began focusing on user groups.

Using data for insights about individual athletes

Participants made two points about why personalization is a preferred future: every athlete's body is different and keeping track of individual athletes data can be more useful for managing training or recovery.

The biological makeup of two athletes might be very different and so tracking data can be used to provide that personalized insight based on heart rate (D2, S4), level of stress on the body (S1), hydration (S4), menstrual cycle (A1), and other individualized data. A1 strongly believes in tailoring tracking technology design and use to the individual:

> *I don't think a one-size-fits-all works for athletes, I do think there needs to be differences between male and female training programs, in addition to just male-male or female-female like training needs to be customized, everybody's different, everyone has different needs...*(A1 in reaction to Informonocle).

D2 described an example of how a one-size-fits-all approach can be detrimental to athletes as individuals whose bodies might be slightly different:

> *I think something for me that's always been big is having more of a personalized approach, so like a personalized baseline. In terms of having the heart rate monitor... some people just have a lower heart rate or they can get it really high... One of my really good friends, she just kind of had a low heart rate. And so she always got marked for not trying hard. I guarantee you, look at her face, she's working harder than some of the other people there. She just is maybe actually more fit than other people, so it doesn't go as high, or something like that. So I think a more personalized approach and more motivation to get better against yourself, rather than put you against your teammates* (D2 in reaction to EnVisible).

A recent longitudinal study of over 90,000 adults shows how heart rate is influenced by age, sex, body mass index and sleep, and that individuals have a resting heart rate that is consistent and normal for them but heart rate can differ by 70 beats per minute between individuals (Quer et al., 2020). If a more individualized approach had been taken in either the design or use of the heart rate monitor (or even better education for the coaches about the human body), then perhaps D2's friend would have been understood to have a lower heart rate than her peers and so she would have been viewed as working hard even if her heart rate was lower.

Differences between individuals like their heart rate is also why heart rate training is used because training can be adjusted for each person to reach a zone that is personalized for them and may even depend on the individual factors for that day (Kiviniemi et al., 2007). S4 describes how his team uses heart rate monitors for training to personalize training:

> *Yeah, I mean, we use heart rate monitors, I mean, I can speak to that, just because I do and I think part of that is there is no more important thing in being an athlete than knowing your own body. And knowing your own body. And a heart rate monitor is incredibly important for that, especially during training, it helps your training be more accurate for you to stay in the training zone that you're supposed to be in. And that's sort of how we introduce it* (S4 in reaction to EnVisible).

The second point participants made about individualization is that without tracking data it is hard to know exactly how much of an impact a training or game effort had on an athlete's body or to measure any other factors that might contribute to increased stress on an athlete's body. Tracking technology can provide insights for managing individual decisions about recovery that coaches might not otherwise be able to figure out or have the time to figure out. S1 described an example based on how her team is already trying to use data:

> *We've been doing it---Oh she played 38 minutes, she needs rest tomorrow. She played 12 minutes, she needs to do more. Sometimes those things are misleading. She played 12 minutes, but they were really intensive minutes and we're full court pressing the whole time and so, while it was only 12 minutes, maybe it had an impact on her body or the load placed on her legs that I'm not aware of and that's where Catapult would check me and be like 'no she needs just as much recovery time as the person who played 25 minutes* (S1 in reaction to EnVisible).

In this example, the technology (Catapult) is able to provide insight about the load on each athlete's body during a game. Without this information, even the coach might assume that the player who played more minutes needs more rest. However, there might be more factors, in this case intensity is the other factor, that the technology helps account for to make sure that each athlete gets the recovery time that they need.

Learning how your "body works" and self-regulating

Related or included in the preferred future of using data for individualization is athletes using data for learning how their bodies work so that they can "self-regulate" (A1).

A1, A4, S4 and D2 all made similar remarks about the importance of athletes learning how their "body works" and using data to help them learn about their body. If athletes can figure out what affects their energy level, how much sleep they need, what they feel like when their body is really exhausted, then athletes can use this information to regulate their behavior for better performance (A4, S4).

A1 calls this "self-regulating" and describes several ways she has learned to self-regulate. One way is using notes from her past training sessions to see where she can improve over time and then making those changes for the next time she does a specific workout. Another is how she learned that lack of sleep really "*throws everything out of whack*" for her so she works hard to maximize her sleep. She also describes how she is able to use her Whoop data to together with her own assessment of how she is

feeling and her coach's help to figure out when she needs to "*dial back*" training and when she can keep pushing:

> *Being able to just refresh a page and get another metric of like I feel like crap today let's see what Whoop says. Whoop says my recovery is in the red, probably not a good idea to hit intervals, I'm going to tell my coach and dial it back. And so, even that is hard, sometimes I'm like "Oh, I can push another day", and then, I'll go to my coach and sometimes he'll reel me and my teammates back* (A1 in reaction to Clippits).

Athletes also need support in learning how to use data to learn about their bodies, how to self-regulate, and general education about the tracking data that is collected and about related topics such as "*nutrition, sleep, and illness prevention*" (A1 in reaction to Informonocle).

A1 said that athletic departments need to "prioritize" educating athletes on these topics. Additionally, the tracking technology companies should also be responsible for providing education on the data and how to use it and significant support for using their products (S5). For example, A1 learned more about sleep and circadian rhythm from listening to the Whoop podcast.

6.3.4. Focusing on trends in the design and use of tracking technology

Embedded in the design of all three videos, but particularly Video #3: EnVisible are the short term effects of behaviors like not getting enough sleep. This has also been my go to example for explaining the tensions around tracking technology in college sports and my concerns around how tracking data could be used. For example, the tension that a student-athlete might feel around needing to make a decision to sleep or study and how a coach seeing that a student-athlete only got four hours of sleep might affect a coach's decisions about that athlete. However, the reactions to the videos describe how not only is this situation not preferred, it is entirely the wrong way to use the data.

To start, short term insights might have no bearing on an athlete's performance: *"You could have an amazing game on like three hours of sleep and you could have an awful game on 10 hours of sleep*" (S5 in reaction to EnVisible). Of course, the reverse could also be possible where an athlete has a terrible game on three hours of sleep and an amazing game on 10 hours of sleep, but either way considering this one data point is not necessarily an indicator of performance.

S1 also describes why focusing on short term insights for sleep might not be useful: "*We're not going to cancel a game because it's finals week and my players didn't get enough sleep. That's just part of it, you know. It happens"* (S1 in reaction to Clippits). If S1 knows that her athletes have to sacrifice sleep during certain parts of the school year and so she knows focusing on this short-term impact to their sleep is not worth focusing on because as she says, "*that's just part of it*."

Taking a different angle, D4 was concerned that focusing on the short term causes athletes to shift their focus from the "*future to now*" (D4 in reaction to Informonocle). D4 stated that his understanding is that athletes would want to focus on progress because "*it's not really about the day-to-day goals, it's about the improvement over time and a history of improvement as well*." If the coach is focused on making decisions or penalizing athletes based on short term data, this compromises athletes focus on their goals of improving their performance over time or on getting good grades if they would have to compromise studying for sleep.

Instead, just as D4 suggests, participants described a preferred future where **trends** are used to inform short term and long term decisions or goals: *As a coach if I could have access to anything, I would want to have access to the trend of the resting heart rate* (S4 in reaction to EnVisible).

S4 was particularly fixated on why he preferred trends over every day data, here is one of three examples he gives about why he thinks trends are important:

> *But then also, like, if you start to see trends, where it's months, like we you know, four weeks that are bad recovery, bad sleep, that sort of thing that obviously makes me alert to look for, is there something up? Is there something wrong? Is there any, you know, illness, injury, whatever, to keep my eyes out for as a coach. And again, I don't know that I want access to all of that. But I think being able to assess trends is important because I don't want to for that young woman, I wouldn't want to see her everyday data because you don't want to fixate on one bad day. I think that's what her concern was that our coaches see, oh, she slept four hours last night. That's terrible. I can't play her or whatever, which is why trends are more important to me because like, you know, alright, fine so you didn't sleep that well for a couple of days because you had, you know, midterms paper due, whatever. But are you sleeping well over the course of the month, do you hydrate well over the course of the week, not just one day, like that sort of thing is more important to me* (S4 in reaction to EnVisible).

The most important takeaway from what S4 says is a trend is a possible indicator that something is wrong. A trend could indicate someone is getting sick or is consistently not sleeping well. Therefore the goal of using the data is more about keeping track of the trends over time to intervene if a negative trend continues—such as giving someone or the whole team a rest if they are fatigued. A1 describes how her coach will address trends in her data:

> *I've never encountered a comment [on my training log] that's like wow why are you only getting five hours sleep. It's more like all right I'm seeing a trend of high resting heart rates, low sleep, and lots of intensity, let's see what we can do to get that resting heart rate down and prevent sickness from continuing to occur consistently* (A1 in reaction to EnVisible).

Also, as S1 describes, an occasional all nighter is not as concerning as a trend and that is where the coach or other staff can see a problematic trend and step in to support the student-athlete:

> *Now if it was repetitive, like this kid for week and weeks and months isn't sleeping, isn't eating, you know, then we have something address, but the occasional cram for an exam, had to pull and all nighter, it's finals week, that type of thing, you'd hope that people can also push through.* (S1 in reaction to Clippits).

There is also the possibility of short term use to adjust training if a person or the team is fatigued or did not sleep well, as described in the section Using data to better and not replace, but it is not necessarily worth doing this just based on one night's sleep or any other one negative point. As S5 says: *There's also better ways of measuring sleep not just like the night before but the week before* (S5 in reaction to EnVisible).

S5 also argues that coaches would need a significant amount of historical data for an athlete to be able to say with statistical significance that certain sleep patterns, in combination with other factors would impact athlete performance:

> *The [scenario in the video] almost seems like blame assignment. And I think coaches are meaning well with this but it is not statistically strong...Unless you start building up a season-long, however-long block you need to validate the data like, 'Hey, your sleep actually correlates significantly with your performance.'* (S5 in reaction to EnVisible).

Given that focusing on trends is a preferred future for using tracking data, this could be incorporated into the design of tracking technologies. None of the participants suggested this directly though S4 had an expectation that the EnVisible system would at some point show the athlete trends in her data. In current tracking data technologies like Whoop and Oura Ring, the design of the app where the user can view their

data forefronts the summary of their data for the current day. For example, a recovery score or sleep score for today is the first thing the user sees rather than a trend. The apps do have graphs that show trends of heart rate and sleep over time but you have to scroll to look at these. Instead of putting single data points from the current day as the forefront, the designers of these technologies could forefront the change over the past week or the past week versus the past few weeks. The designers could also help the users understand what is a significant trend or not. For example if they saw +5% or -5% that might not be significant to cause concern but if they saw +/-10% or more, something like that they would know something was wrong. Of course there is also the case of a good trend that might indicate an athlete is well rested in which case they would know they can push themselves harder than they are currently.

6.3.5. Discussion: Making the preferred futures for data interpretation and use a reality

The reactions that described preferred futures for tracking data interpretation and use—taking a holistic approach to data collection and use, augmenting and not replacing human expertise, and focusing on personalizing insights from data and trends in the data—already included some suggestions that could make these preferred futures a reality:

- **Holistic approach:** Adding collection of athlete self-reported data that can help form a more holistic view of an athlete.
- **Augmenting and not replacing human experience:** Designing to augment coaches observations in real-time, designing to prompt coaches to consider their own expertise when reviewing and interpreting data, educating coaches on how to combine their expertise with the data.
- **Personalizing insights:** Adding support for collecting and providing insights based on personal physiological data like menstrual cycles, educating athletes and coaches on how personal differences may show up in data and how to use these, and designing to support decision-making around an individual athlete's needs (e.g., which athletes need more rest than others).

- **Focusing on trends:** Putting trend graphs as the forefront of interfaces for reviewing data and educating or supporting coaches and student-athletes in understanding when a trend is something they should take action on.

Reviewing these preferred futures and suggestions alone, the main design barriers to making them a reality is working through the design specifics, making sure the data interpretations are useful, and figuring out how to best educate student-athletes and coaches on the topics needed. However, these preferred futures include both student-athletes *and coaches* having access to tracking data and, as Section 6.4 will describe, the tensions identified in Study 1 and further nuances discussed in this study pose problems for managing who has access to tracking data, when they do, and how it is shared. Nevertheless, Section 6.4 will also present opportunities where designing to support these preferred futures and more education or expectation setting around data use could possibly balance or resolve tensions between student-athletes and coaches around data. For example, student-athletes seem to hold a fear that coaches will punish them if they do not get enough sleep one night. It is important to note that student-athletes might view an action taken by the coach to bench them from practice or a game due to lack of sleep as punishment, but, from the coach's perspective, such an action is a decision that supports the team's goals and the athlete's long term safety and recovery.

If coaches set the expectation that a trend of poor sleep is a concern and not a single night, then athletes might be more willing to share their sleep data, especially if the design prevents a coach from seeing night-by-night data and instead raises an alarm only when an athlete has slept poorly on half or more of the nights from the last two weeks.

Taking a step back to look at the larger picture for the future of tracking data interpretation and use, there are two additionional concerns that should be considered: validity of tracking data and proper data interpretation (Karkazis & Fishman, 2017).

These concerns are raised by ethicists Karkazis and Fishman in their paper on ethical concerns for using tracking data in professional sports (Karkazis & Fishman, 2017), but data validity and proper data interpretation should be a concern in any context.

Validity is a concern because the user must be able to interpret and rely on the "truth" of the data. In the context of sports, if a measurement like heart rate is not accurate then the technology is useless or if the inaccuracy is unknown then using that data could endanger an athlete's wellbeing. Similarly, if the data is not interpreted correctly, even if the data itself is accurate, this could have dangerous consequences. Proper data interpretation is a further concern because if the data cannot be interpreted properly then the technology wastes a team's time and money. The following subsections will elaborate on these concerns.

Validity of tracking data

As previously stated, validity is a concern because the user must be able to interpret and rely on the "truth" of the data. In the context of sports, if a measurement like heart rate is not accurate then the technology is useless or if the inaccuracy is unknown then using that data could endanger an athlete's wellbeing.

However, companies designing tracking technology for sports are inventing new measures such as "recovery score" and "strain" from Whoop or "body battery" from Garmin. These measures are calculated based on scientifically valid measures like resting heart rate (RHR), heart rate variability (HRV), and other data like time spent in different stages of sleep. Though RHR, HRV, and sleep tracking have been validated for these technologies (Bellenger et al., 2021; Chee et al., 2021; D. J. Miller et al., 2020), the algorithms these companies use to combine RHR, HRV, sleep, and other information are proprietary and validating measures like Whoop's "recovery score" are outside the scope of current research (Bellenger et al., 2021). This raises questions about accuracy and validity of the insights that Whoop and other companies provide.

Without validation of these proprietary measures, there are two potential outcomes. The first is deciding not to use or rely fully in these measure such as one staff member from Study 1 who described recognizing the value that was being calculated by a system as a valid measure for knowing whether or not athletes are overtrained and at risk of injury, but he was unable to use the value provided by the system because he could not be sure how the system calculated it. The second possibility is that the measures will be used regardless, which is potentially dangerous, especially when the CEO of Whoop and his VP of Data Science and Research admit on their podcast that they were able to create their recovery score metric because they were not held back by the pace of academic research[25].

In team sports or any other context, stakeholders need information about the accuracy or validity of the data or algorithms processing the data. The dangers for college sports may be less obvious than a situation where machine learning might fail to diagnose cancer (Cai et al., 2019), but as athletes and coaches are increasingly relying on tracking data to make decisions, valid data could save an athletes' life just the same as invalid data could result in a decision that leads to serious injury or maybe death.

Proper Data Interpretation

As previously stated, improper data interpretation could have similarly dangerous consequences to invalid data. Chapter 1 also set up the interpretation of data as part of the motivation for studying tracking data in sports. As written in Chapter 1, there are an ever-expanding number of tools being built for collecting and analyzing data about athletes that all claim to be able to provide great insights, improve player and team performance, prevent injuries, and so on, but if athletes and coaches are struggling with which tools to adopt and how to use the data, then they will not be able to use the technology to realize those goals in practice. Thus, tracking technologies need to be designed so that users can properly interpret and make use of data.

[25] Whoop Podcast #14: The Sleep Episode (Will Ahmed, Whoop CEO) and the guest Emily Capodilupo (Whoop VP of Data Science and Research) discussed how they were able to create their recovery score metric because they were not held back by the pace of academic research, see https://www.whoop.com/thelocker/podcast-14-sleep-director-analytics-emily-capodilupo/.

In my conversations with staff as a part of Study 1, staff members described lack of resources—time, education, or money, funds to hire a consultant to help them analyze the data—as barriers to understanding and using the data they are collecting about their athletes. In this study, Study 2b, participants indicated that preferred futures would include the designers taking responsibility for making the data understandable and usable (S5, D3). The designers likewise acknowledged that the users do not necessarily have the knowledge needed to interpret the data (D4) and that their focus should be to provide information that is "useful" (D5) to people without specialized knowledge (D3).

Also, as described at the beginning of this section, the preferred futures for data interpretation and use provided some information on what data and insights would make data useful to college athletes and coaches: a focus on trends, personalization, and augmenting a coach's observations with data. However, further research is needed on how to design for these uses and for how designers could craft a "whole experience" (D3) around the tracking technology that might include:

- Providing insights using basic statistics or AI and machine learning techniques (D3).
- Education on the data and insights provided by the technology in a way that addresses the time constraints of the athletes, coaches and staff (S1, S5).
- Education for athletes, coaches, and staff about how the data and insights can or cannot be used (Examples from S5: correlation does not imply causation, what data can or cannot be used to understand athletes fatigue).
- Resources for supporting athletes, coaches, and staff in using the data, such as a database of help documentation, a network of peers, or designated experts that support college teams (D3).

Implementing the above suggestions does pose additional problems. For example, college teams cannot all afford experts to help them analyze data but if companies hire more experts to help teams analyze data then the cost of the technology or service itself will increase.

6.4. Preferred futures for tracking data management

The reactions to the videos suggest that the preferred futures for how to manage tracking data on college sports teams will require significant reconsideration of current design and use of tracking technologies and further discussion to figure out how to balance the needs of student-athletes and coaches.

Student-athletes and staff preferred restricting tracking to training or anything currently under the 20 hours per week allowed by the NCAA for training and competition. Despite this preference for privacy outside of training or competition, both student-athletes and coaches expressed needs for sharing data from off time. Student-athletes' preferred futures also include having agency—the ability to opt-in or opt-out of sharing their data—which was recognized as a way to address the tension between the need for privacy and sharing data because athletes could choose to keep their data private. However, reactions to the videos also indicate that the option to share data was flawed because student-athletes view optional as not optional if the instruction comes from their coach.

Both the videos and the majority of reactions to the videos leave the preferred futures for data management unresolved. However, there were reactions to the videos that point to new ideas for preferred futures for data management: 1) A team culture around setting expectations for data use and having open communication around data, 2) A distributed model of data sharing, and 3) New data interactions built into the design of tracking technology. Section 6.4.5 will discuss these ideas and how to move towards finding a preferred future for tracking data management.

6.4.1. "My life is my life": Preference for tracking only during training

Several participants agreed that one preferred future for tracking data management, specifically when data should be collected, would be to restrict tracking to during training or anything currently under the 20 hours per week allowed by the NCAA for training and competition. This is based on student-athletes'

need for and a right to privacy (A2, A3) that coaches want to respect either out of personal opinion or the rules (S4, S5).

A3 described how his preferred future included being given a tracking device at a training session and then having to give it back at the end of the session. He is comfortable with this because training time is a time when he should be doing whatever he is told to do. It is not the athlete's job to decide what to do at training time, it is the coach's, so A3 does not see an issue with being tracked during training time. A3 also specifically states that he would be uncomfortable with tracking anything outside of training:

> *I never have an issue if it's practice time because practice time is practice time, training time is training time. You can do whatever you want, tell me whatever you want in training time—I'll do it. But I think in this video where [the student-athletes] hold on to [the tracking device]. Maybe it's something you give at practice and then take back after practice...But when you start having to get into everything that I do outside of the game, then it gets a bit uncomfortable for me* (A3 in reaction to Informonocle).

A2 shared A3's perspective and did not object to tracking during training, but A2 did not share A3's discomfort with being tracked outside of training. A2 felt that tracking data outside of training, like sleep, would be critical to providing a coach with an understanding of his recovery, so he understood why the tracking outside of training could be useful. However, A2's objection to tracking outside of training is with the tension he felt between knowing the value of the tracking data with having his life and his decisions be his own outside of practice:

> *It's not uncomfortable to have a coach monitor my sleep because it is something that's super important to recovery. But it also is kind of that fine line and slippery slope of, 'Hey, my life is my life.' I know I can operate off of seven hours of sleep and maybe one of my teammates needs nine hours of sleep. So it's kind of that weird balancing act that I think is a tough thing to decipher* (A2 in reaction to EnVisible).

To unpack what A2 is saying a little further, he is comfortable with having his coach monitor sleep, but he also feels that his coach might judge him based on how much sleep he gets and he wants to retain his ability to decide his own sleep schedule. This tension felt by A2 is key to the tensions discussed throughout the rest of Section 6.4 and in Chapter 7. This tension between privacy and sharing a data stream that is important to athletic performance is also why sleep data is used repeatedly as an example. However, there are other data streams, including ones collected during an athletic performance (e.g., concussion data, continuous heart rate, location) that athletes might also prefer to keep private.

S4 and S5 also agreed that tracking should not happen during athletes' off time because it would violate NCAA rules and violate their privacy.

S5 had a strong reaction to the idea of using a tracking device outside of practice which he refers to as an "encore training tracking device": "*I almost stopped watching like 30 seconds in...I don't know endurance sports as well just like time commitment deal. But it'd be like a huge no-no for us to use an encore training tracking device for their optional practice*" (S5 in reaction to Informonocle).

He cites the NCAA rule that limits the number of hours a week that student-athletes can be required to take part in athletic activities to 20 hours and that within those 20 hours "*it's expected that the athletes are just doing what they're told to do*" (S5 in reaction to EnVisible), so tracking athlete's during off-time would be "*totally not okay.*"

Regardless of the NCAA rules, S4 was personally against data tracking outside practice which he states in three different ways in this quote:

> *I personally just don't agree with tracking anything outside of the workouts, like, I don't know, I'm big on personal privacy. And I just don't agree with it...I think that it's an invasion of personal space, which I'm not very big on* (S4 in reaction to EnVisible)

Also as described by D1 and S4 in the Section 6.5.3, student-athletes also need time away from the coach and team and a separation from always being "on".

6.4.2. Student-athletes want the option to share their data to have agency and preserve privacy

Despite student-athletes' and coaches' preferences for privacy and restricting tracking to training or competition, Section 6.3 noted several preferences for sharing data outside of training or competition or preferences that would require, or benefit, from collecting data during off-time: a holistic approach to tracking, using data to inform a coach's decisions, and using trends to identify when an athlete might be struggling.

The conflicts between the preferences for privacy and sharing pose a dilemma for how data should be managed. Video #3: EnVisible was intended to portray this conflict and the knowledge that a binary approach—sharing everything or nothing—is not a preferred future. If no tracking data was shared, this would maintain the athlete's privacy, but this does not account for further nuances around the possible benefits for sharing data with the coach as described in the previous section. If all tracking data was shared, this could create accountability and trust on the team and the data could be used to the benefit of the team, but this would violate athletes' need for privacy and right to off time.

To address this dilemma, Video #3 proposed a preferred future that gives athletes the agency that they lack in the current use of tracking data (see Chapter 4) by giving them the option to share their data or not. The student-athletes' reactions agree with the preferred future of Video #3 as they confirmed that sharing their data, especially data from off-time, would take away their agency and ability to make their own decisions and so having the option to share was preferred.

A1 and A4 reflected on how sharing their data would limit their agency to make their own decisions:

> *Let's say you have a choice between going to bed at 9 or doing things that could impact your recovery and you're like dang my coach is going to see this in the morning I should probably just go to bed...I think it would take the self-autonomy away from you making your own decisions for fear of like being punished and being judged* (A1 in reaction to Clippits).
>
> *The more metrics you're sharing with someone, the less privacy you feel over your body, and like over, I don't know, your agency and things like that, the independence as an athlete* (A4 in reaction to Clippits).

Similar to A2's comment from Section 6.4.1, A1 and A4 are touching upon a key problem for student-athletes when it comes to sharing data outside of practice and the key tensions that was portrayed by Video #3: student-athletes are afraid of being judged by their coach based on their data because the demands on their time as student-athletes might prevent them from doing things that are in the best interests for their athletic performance. Student-athletes face this constant battle in their decision making (S2)—"*that balance of staying up late studying, but then, you also need to balance that with getting enough sleep because you want to look good to your coach*" (D1)—because they do not have the time to get everything done that they need (S1).

Student-athletes need agency to be able to make the decisions they need without fear of judgment of "looking bad", so it was unsurprising that all the athletes who reacted to the videos preferred having the option to share their data: "*I did like how it was optional to share the data*" (A1 in reaction to EnVisible), "*The asking part would make me more comfortable using it*" (A3 in reaction to EnVisible), "*Asking for, like to double check, 'Hey do you want to share this or do you not want to share?' I think that's something really crucial*" (A2 in reaction to EnVisible), "*I like having the ability to choose what functions you want to use. And then if you want to keep it private or share it I think is really important as well*" (A4 in reaction to Informonocle).

A3 also added that the option to share was preferred because asking permission is "*more ethical*", rather than being automatic he is "*in that position like 'oh hey', I like how they asked me even though it's like an extra step in my day. And I think that's the cool part for that [technology (EnVisible)]*" (A3 in reaction to EnVisible).

However, though student-athletes preferred having control over sharing their data, whether the student-athletes would actually choose to share or not was a different story: "*I really can't say whether I would personally say yes or no. Because I think it just depends on honestly a bit of my mood that day, what I'm doing, and all that sort of stuff*" (A3 in reaction to EnVisible). S2 similarly thought that the athlete might not be "*thinking straight*" early in the morning so S2 suggested asking at a different time when the athlete is more awake and can make a "*proper decision*".

Additionally, D2 and S2 both perceived problems around the way EnVisible was asking the athlete to share their data. D2 asked, "*It's like are you gonna ask that every time?*" in response to how EnVisible was asking Anne to share her data. She thought if the technology asks "*every morning when I wake up and I'm on like day five of not sleeping well and I'm sick of seeing that, Am I gonna do it just so I don't have to deal with that?*" (D2 in response to EnVisible).

This exact question was what we intended in the design of the ending to Video #3: EnVisible. If the technology is repeatedly asking you to share and the coach is too, then the athlete might give in so that they would not have to deal with being asked. This pressure to give in also leads into the question posed by Video #3: Do athletes have a choice to share their data? The next section will address this question in detail.

6.4.3. Optional is not optional

Providing athletes with the option to share and giving them agency where they previously had none was preferred because it offers the ability to balance the need for privacy with the need for sharing data. However, this idea has a major flaw: optional is not optional for student-athletes due to real or perceived pressure from coaches and teammates.

Choosing not to share is seen as having something to hide

Participants pointed out flaws in the idea that sharing could be truly optional because they perceived that not sharing is the same as saying I have something to hide, or it could create a lack of trust or issues of favoritism for athletes that do not share their data.

A1 explains "*In a perfect world if everyone is able to get 9 hours of sleep every night, I think having the option to share with the coach could be awesom*e", however, "*if you're sharing data and then also you turn it off it's like very obvious that you didn't want to share it and so I think it will lead the coach to make assumptions based on why you didn't want to share the data or lead you to feel guilty or lesser than your other teammates if they're all sharing and throwing up beautiful sleep scores*" (A1 in reaction to EnVisible).

Similarly, A2 said that not sharing would "*raise a red flag*" with the coach. This in turn could lead to a conversation that might question an athlete's integrity or trustworthiness. Both D1 and A2 imitated how they thought a coach might approach an athlete who was not sharing their data: "*Why aren't you sharing [your data]?*" (A2 in reaction to EnVisible), "*Cough up the truth, you're not sharing the data so what's actually happening?*" (D1 in reaction to EnVisible).

Additionally, in contrast to the idea that sharing data could support accountability, D1 called out the dialogue from the video, "*What is she hiding?*" as being accurate to how a coach or teammate might feel knowing that an athlete is not sharing their data.

Optional sharing could result in favoritism

Another flaw of optional sharing as a preferred future is that data sharing could result in some athletes being favored over others similar to how star players might be favored over the rest of the team (D2). D2 states how optional sharing could be used as an indirect penalty to pressure athletes to share their data:

> *'Oh well, we're not going to penalize you but we're going to favor everybody who does it.' So I've experienced that a lot as a student athlete where it's optional but it's not optional*
> (D2 in reaction to EnVisible)

Therefore, the option to share might not be so optional after all if athletes feel pressure to share. And so, this leads back to athletes in the same situation where sharing is not optional at all and athletes do not have a choice.

Student-athletes do not have a choice

S3's first reaction to the EnVisible video was that sharing "*is not truly optional, they say it's optional but pressure from their peers sharing data and then even the coach saying it's optional but then saying it could help the team puts undue pressure on [the athletes] to participate and there's a fear of consequences if they don't participate*" (S3 in reaction to EnVisible).

The reasoning that S3 gives for why sharing is not optional is due to pressure from coaches or teammates and the fear of consequences if they don't participate in tracking. This is a succinct summary of the reactions I presented in the previous sections. Pressure from coaches and teammates feeling an athlete is hiding something or even from the technology asking repeatedly could make the athlete feel like they do not have an option. Similarly, consequences such as sharing influencing the coaches treatment of an athlete could make an athlete feel like they do not have a choice.

These "*influencing factors*" as S3 says removes the "*whole notion of agency that players have to provide data or withhold it.*" In other words, the option to share data is a false choice:

> *Even though they technically have the autonomy to make the decision, they actually don't really given the influencing factors. So one [concern] would be around boundaries and what data is okay, and then the second [concern] is are they actually being given the right situation to make the decision to provide it or not* (S3 in reaction to EnVisible).

This raises a question of whether athletes can be given the right situation in which they are truly able to make the decision to share or not.

Another important notion I want to draw attention to is that tracking athletes is perceived as normal and expected such that choosing to opt out of tracking at a workout would not be an option: *There's other tracking stuff that we're able to do, but the general attitude on the on-court stuff, on that data, is that's just an expectation, you're on the team, you're contributing, you're gonna be wearing the sensor* (S5 in reaction to EnVisible).

Likewise, S4 describes that wearing a heart rate monitor during workouts is not optional: "*It's not optional to wear a heart rate monitor during our workouts, you're wearing a heart rate monitor for you know, most of our steady state and everybody across the board is doing it. No exceptions*" (S4 in reaction to EnVisible)

Furthermore, outside of practice, optional can mean expected. S5 points out the scenario from Video #1: Informonocle and how the secondary runs were not optional. This was based on a real way that coaches are able to get around the 20 hour NCAA rule and training during the off-season. S5 held up his fingers in air quotes saying, "*[The athletes] 'design their own plan without the coach's guidance'*", which he immediately followed up with "*make sure you capture the quotation marks there.*" He is saying that it is understood that the coach creates a training plan and assigns it even for off time when the team is

technically not supposed to have any influence on what that athletes are doing. The reason that the work around is used, S5 describes, is that to be successful at your sport you need to do it year-round and perhaps more than the allotted 20 hours per week so the additional workouts or off-season workouts are positioned as optional.

A4 described that she accepts that tracking during workouts is not optional, but her preferred future would include "*more personal stuff...like nutrition*" to be optional. This also possibly implies an idea I will return to that new tracking devices are different from traditional methods of accessing athletes so the idea of tracking as normal and expected is something that should be reevaluated. S5 specifically mentioned that in regards to the use of tracking data by his team, there has not been any discussion about "*is this a good thing or not? Do [athletes] have a choice about it?*" If these questions have not been thought through by teams or designers, then further discussion or research on how expectations might need to change is warranted.

6.4.5. Discussion: Finding a preferred future for managing tracking data

The findings presented in this section pose a challenge for finding a preferred future for managing tracking data that can provide athletes with privacy and agency while also sharing data so that it can be used in the preferred ways described in Section 6.3. This section first revisits why it is important to find a balance here and then discusses some new approaches.

Coercion: More than a lack of a choice

I want to reinforce this finding that optional is not optional because student-athletes may not realize that they are being coerced and finding a preferred future for managing tracking hopefully does not include coercion of student-athletes.

On sports teams, data collection and sharing has long been a social norm. Terms like “athlete monitoring” and “injury surveillance” are used to describe this data extraction from athletes that is

justified because it supports both team and individual goals (see Section 2.3) by, in the best case, keeping athletes healthy and improving performance. (Karkazis & Fishman, 2017; Kolovson et al., 2020).

This exercise of surveillance matches Foucault's descriptions of disciplinary power, which focuses on the control and discipline of bodies through training activities, schedules, observations, and judgment (Jones et al., 2010). Furthermore, coaches can see disciplinary power exercised through monitoring or surveillance as necessary to be effective as they need to manage risk and maintain control related to the team goals:

> "One way disciplinary techniques become enacted by coaches over their athletes is through the idea that overseeing and **monitoring an athlete's training is a vital aspect of effective coaching**. However, control also comes through the coach's gaze and various technologies of surveillance; control that can be maintained by the all-knowing coach which positions the athlete as a subject to the coach's 'expertise' and knowledge" (Jones et al., 2010, p. 33)

Athlete monitoring is, in general, advantageous for athletes and teams as they are united by the same goals that monitoring supports (Karkazis & Fishman, 2017). Campbell & Carson also describe surveillance in the online consumer market as a way of managing risk by knowing more about the customers buying your products (Campbell & Carlson, 2002). The motivation is similar in sports organizations, as managing risk includes avoiding losing competitions and financial loss when athletes are not able to play and loss for the athletes when injuries affect their career, life and overall well-being.

Athlete monitoring for risk management supports organizational goals but it also supports individual goals as it keeps athletes healthy and results in improved performance (Karkazis & Fishman, 2017; Kolovson et al., 2020). This support of an athlete's goals creates an "Illusion of Voluntariness" (Campbell & Carlson, 2002, p. 592; Davies, 1997, p. 143) where athletes "buy-in" to surveillance because they think it will benefit them in the long run and because of the pressures to perform (Karkazis & Fishman, 2017) or the threat of exclusion otherwise (both organizational coercion).

The concept of an "Illusion of Voluntariness" comes from Simon Davies, but I build off how the concept is described by Campbell & Carson (Campbell & Carlson, 2002). Campbell & Carson argue that people willingly engage in self-surveillance for two reasons: 1) They think they will benefit; 2) They are subtly coerced by the threat of exclusion. I think a similar illusion and exclusion exists in sports.

In this chapter and previously in Chapter 4, I describe how student-athletes participate in tracking their own performance because they see the value in the potential for personalized insights, improved performance, and protecting their wellbeing. Karkazis and Fishman say it is the pressure to perform and stay healthy that profoundly influences an athlete's "autonomous" decision to accept risks. Prior to tracking technologies this pressure incentivized "playing through the pain," but, now, incentivizes submitting to invasive and ongoing surveillance (Karkazis & Fishman, 2017). Student-athletes, above all, want to compete in their sport so they "volunteer" their information willingly so they are not excluded, but in some ways they are selling their bodies and minds. And though their desire to compete may make sharing their data with staff seem voluntary, they really do not have a choice to opt-out unless they are willing to quit playing.

If optional is not optional, then extraction and obfuscation are back again

If organizational coercion prevents student-athletes from having the option to share their data, even when the tracking system provides it, then this is the same as data extraction described in Chapter 4. Data extraction reduces athlete agency which, as the beginning of this section (Section 6.4.3) describes, is not preferred.

As Study 1 also describes, lack of agency could result in student-athletes distorting their data. This is also known as *obfuscation*—"the deliberate addition of ambiguous, confusing, or misleading information to interfere with surveillance and data collection"—which is used by the weaker side of an information-power relationship to combat information asymmetry (Brunton & Nissenbaum, 2015).

In the context of college athletics, the weaker side of the information-power relationship is student-athletes who, lacking power to opt-out of data collection and access to their own personal data, might use obfuscation to resist. Distorting, lying, or providing misleading information may be the only defense against coercion and surveillance—Brunton and Nissenbaum cover ethics of obfuscation in their book—but if athletes choose to obfuscate then tracking data could be rendered unusable.

The second aim of my dissertation is to find a way to balance the needs of different roles around tracking data. As identified previously, student-athletes want agency to make their own decisions. To move forward in finding a preferred future for managing tracking data, the key is to find a way to support athlete agency in the design and use of tracking technologies *without obfuscation* so that the integrity of the data can be maintained and the coaches or others can use it.

Considering Appropriate Flow of Information instead of Privacy

To move forward in a preferred future where tracking technologies are designed and used without (or less) coercion, extraction, or obfuscation, I suggest that designers and teams should consider *appropriate flow of information*.

The term *appropriate flow of information* comes from Helen Nissenbaum. Nissenbaum suggests rejecting the idea that control over personal data is privacy and instead privacy should be thought of as *contextual integrity* where privacy is dependent on the norms of the context that determine *appropriate flow of information* (Nissenbaum, 2004). If tracking and surveillance of athletes is a norm of college athletics, then that norm could indicate that sharing all relevant data, including that from tracking technologies, is *appropriate flow of information*.

However, tracking technologies enable new streams of data collection that athletes may wish not to share because they are about their own body or might give insight into their private life. For example, norms of data tracking and sharing in sports started when the data being collected was public knowledge

(e.g., you can go to a baseball game and count how many hits a player gets). Data being collected by tracking technologies is more personal, and related to activities that happen behind closed doors, such as sleep quality.

Even though these new data streams may still be relevant to team goals and coaches need to monitor their athletes, the athletes may feel this is an inappropriate flow of information, but the social norms of monitoring have yet to be renegotiated either socially or in the design of tracking technology:

> *I think the technology itself is okay. I think that it basically being a wholesale, you can share everything or nothing. It was a little uncomfortable like that. That didn't feel right... I don't know that I agree with the technology to where it's like you can either share everything or nothing. I think that there's some amount where sharing is appropriate, and some are worth not* (S4 in reaction to EnVisible)

S4 specifically supported a preferred future where there was a more granular approach to data sharing that goes beyond all or nothing. This quote is from S4's reaction to EnVisible where the student-athlete, Anne, had control over sharing her data and could turn it on or off as she pleased but the control was still an all or nothing option. So I think that S4 is not only saying that data sharing needs more than an all or nothing approach but he is also saying that the option should be around the types of data and choosing which are appropriate to share.

The following are some ways in which designers and teams could re-think the flow of information or the social norms around tracking:

A distributed model for data visibility or sharing

A preferred future for data visibility and sharing that might take some pressure off of the coach-athlete relationship is the idea of distributing data to other athletics staff and/or specialists. Based on their role, these other staff and/or specialists would be responsible for reviewing and supporting the athletes with

different types of data (e.g., Many college athletic departments have a psychologist who could intervene by looking at trends in sleep and a nutritionist who could support student-athletes by reviewing food choices together).

A4 suggested this approach and how it would make her feel more comfortable to share certain data types with other people who are not her coach:

> *I think it could be helpful for information to be, like, shared with the specialist in that field. Like, I would feel more comfortable having a nutritionist like view, like the calories I'm eating or something like that, because they're gonna view it through a lens of like, okay, how can we help her stay healthy? By like, how she's eating versus like, a coach might view those numbers, if they're like, particularly obsessed with, you know, like, the number of calories. [The coach] could be making you feel bad for eating something versus a nutritionist might be like, okay, like it happens. And things like that, or like a therapist, if they, like the view have seen, like, let's say you weren't able to run very much. If you weren't feeling well, for the week, then they'd be like, oh, like, what's going on? Like, mentally? Are you okay? Versus a coach might see that as more like, okay, like, they're just weak, like, they're not doing well. So I think like having specialists see them, I would feel more comfortable with that* (A4 in reaction to Clippits).

As A4 describes, the coach is not always the best person to help with every problem. A specialist might take a different approach that would be better for the athlete to address a problem. Additionally, this distributed approach could prevent any fear that the student-athletes have around their data influencing how their coach views them.

Distributing the data to other roles or specialists might also prevent the data from giving the coaches more power over student-athletes or reinforcing the power dynamic. Though coaches like S1 and

S4 say that they would not want to see all their athletes data and that they do not have the time or expertise to deal with it, A4 was concerned that coaches always want more information:

> *I think probably the coaches would still want to see it. But I think being able to, like, share with having the choice to like, share with other people besides the coach could be helpful. Yeah, because like, that's what the data should be used for... because I feel like the coaches, as I've said before, many times, like can have a lot of power over the athletes and make them feel kind of isolated in some ways* (A4 in reaction to Clippits).

S5 also commented on the idea of distributing data to different roles or specialists and viewed figuring out this distribution of data and responsibility as a key part of figuring out how to use tracking technology. He says what needs to be figured out is which "*intermediaries*" need "*data rights*" and what data (type and level of granularity) they need access to. He says that some roles may have "*more data rights than the coach*", especially the athletic trainers who "*should probably have the most access*" (S5 in reaction to EnVisible).

This study purposefully focused on the interactions between student-athletes and coaches around tracking data, so I cannot comment further on how data should be distributed to other roles. However, it should be explored in future work as it is promising for balancing the needs for privacy and sharing and issues such as the coach's lack of time or expertise to handle all the tracking data in addition to their current responsibilities.

Design new interactions with the data

For a preferred future for managing tracking data, sharing all or nothing or having an all or nothing option to share data is not enough to account for the social dynamics at play around the tracking data. A few participants described some ways the design could better support the social nuances.

Design different ways of representing the data that balance the needs of coaches and athletes. S5 suggests that there is more than one way that data could be represented to different roles on the team. Different data representations could perhaps be employed to address the needs of the athlete and the coach:

> *If you need to protect individuals by anonymizing [the data] to a degree, where it's still useful, I think coaches are going to make that sacrifice because at the end of the day this becomes very un-useful if the trust between the student-athletes and the coach is broken, right?* (S5 in reaction to EnVisible)

S5 also described how the trainers might need specific information to do their job and treat the athlete, but given that the coaches might not need to know as much they could get "*a less specific view*" of the data.

Both these ideas suggested by S5—anonymizing and abstracting how data is viewed—were ideas that I had prior to the start of the study. However, these suggestions from S5 were completely unprompted as I did not say anything that would have influenced S5 in suggesting these ideas. Of course, my ideas were woven into the design of the videos and though data was not anonymized or abstracted in the videos, it is possible that my ideas could have had an indirect influence.

Design the ability to pick and choose data types. Another suggestion was designing for the ability for athletes to pick and choose data types that are tracked or shared. Both A4 and D5 discussed this idea as preferred for the design of tracking technology:

> *I would be totally open to doing a pick and choose of like the options I want [to track]. I think it could be helpful to have, I don't know, like, I'm trying to think of which of the options I would use...I think sleeping might be helpful for recovery. Maybe nutrition tracking, like macros would be helpful* (A4 in reaction to Clippits).

> *So if the [Clippits] can detect and manage many data types at one, that represents the clips, then maybe it looks like they can manage what kind of sensor that we have. And maybe they can choose what kind of data they want* (D5 in reaction to Clippits).

The ability to pick and choose which data types are tracked and shared does not entirely remove the problems with optional data sharing, but it provides an additional layer of granularity such that S4 was looking for rather than just the option to share all or none of the data.

Furthermore, if the team were to discuss and decide on which data types to track together, this would support the preferred future of open communication and setting of expectations in regards to the use of the tracking data.

Supporting positive team culture and open communication around tracking data

D3 posed what she described as a design question: "*Is there a way to build a sense of warmth or 'teamliness' or something that's not creating a toxic environment if you're going to have some sort of data or performance-based product?*"

This question came out of D3's reaction to Video #2: Clippits where she gave two examples from her experience where a specific approach was used to bring the team together and it was successful when the team embraced the approach together.

In the videos themselves, we did not aim to represent any truly preferable interactions between coaches and athletes around their data. The negative interactions portrayed or other elements of the scenarios prompted participants to share examples of similar interactions such as how athletes feel looking at data, the pressure put on athletes that would lead them to do anything the coach asks, or the fear of how a coach might use tracking data.

However, the scenarios also prompted participants to reflect on examples of positive interactions from their own experiences and to describe a preferred future for how team culture should be set up around technology that includes a value of open communication around tracking data. It is these thoughts that might inform D3's design question.

There were two overall reactions that inform D3's design question. The first was the importance of establishing how the tracking data would be approached by the team. S2 said "*creating a positive atmosphere around [data] to begin with could ease concerns and the anxiousness that arises out of it.*" Similarly, A1 suggests adopting "*an aura of humor around [the data] that is going to create much healthier, happier athletes that are more adaptable to general life stressors and stressors around data collection.*"

Setting this approach could come from the design of the tracking technology (S5), a representative from a tracking technology company that works with the team (S5), the coach (A1), or the athletic department (A1).

The second set of reactions that can inform D3's question are suggestions for how to support "open communication" (A1, A2, D1) and expectations around tracking data.

A3 suggests that facilitating open communication starts with having an initial conversation with everyone involved to set expectations for what data will be tracked and how it will be used:

> *Maybe if it's with the entire coaching staff and not just a single coach, plus any medical team involved, and even the sports psychologists involved, kind of a team effort and transparency to create a team-wide---"this is the kind of level we're looking at and this is the level that you need to be at"* (A3 in reaction to Informonocle)

A2 also suggests that part of this initial conversation could be working with each student athlete on a plan for achieving their goals or the expectations of the coaching staff. And A1 would prefer an approach to

this initial conversation that emphasizes (for athletes) that the tracking technology is a "tool to manage yourself" (A1).

After this initial conversation, open communication needs to be normalized and supported by the coaches and staff and perhaps the technology itself or an educator employed by the tracking technology company.

D1 describes what an open conversation might look like. An athlete might say "*I had a really shitty week. I had two midterms, I'm just going through it right now.*" Then the athlete could be supported in coming up with a plan of how to move forward from there.

These reactions only scratch the surface of how D3's question could be addressed. Further research into this particular question would support a deeper understanding of how to approach a team culture around tracking data and facilitate open communication.

6.5. Preferred futures for supporting athletes' mental health

The reactions to the videos suggest that supporting student-athletes' mental health in relation to tracking data needs to be part of preferred futures for the design and use of tracking data. In addition to the pressure that student-athletes are already under to perform well academically and athletically, tracking data poses concerns for athletes mental health and overall wellbeing. The reactions to the videos describe how tracking data can increase a student-athlete's anxiety and feelings of falling short and how to reduce this harm through the design and use of tracking technologies.

The preferred future of protecting student-athlete's mental health was intended as part of the preferred future for Video #1: Informonocle. However, Video #2: Clippits also drifted into this theme by showing how more or less tracking data could affect an athlete's day. Video #3: EnVisible did not specifically focus on themes of mental health and wellbeing, but Video #3 sparked discussion around

these themes regardless. I want to draw attention to these details because the participants overwhelmingly discussed athlete mental health and wellbeing even though we did not originally intend this to be a major theme in the design of any of the videos.

6.5.1. Preferences for more or less data

S1, a head coach, summed up the challenge for a preferred future where athletes' mental health is supported in regards to tracking data: "*more information can set you up for success and set you up for failure*."

S1 and S4 both remarked that athletes respond to data differently. Some people are okay seeing information or knowing that they might not be perfectly set up for success on a given day but they are not going to let that affect them, especially on a game day. Other people might think they are going to fail. Or the same individual might experience both of these attitudes at some point. This also aligns with the preferences that participants expressed for or against data.

A4 is one of those athletes who prefers less data: "*I think this is because my personal preference is that I don't like to have a bunch of data for myself just because sometimes it's a little excessive and I think I can kind of get controlled by it in some ways*" (A4).

D3 prefers the opposite as she is a person who thrives with more data: *I was thinking about how it can be motivating, I guess to wear a badge of honor that you did something right or that your training is going well. Well it could be a badge of honor or it can also be like "Oh coach likes you" or whatever. But for my personal life, as like my own self, I think that would be really cool to be like, oh, yeah, I'm like ticking all my boxes and getting all the sleep I need. Whatever. So I get to like, show it off, I guess* (D3)

A1 and A2 were more in the middle because they viewed data as a "*double-edged sword*" (A1 in reaction to Clippits) that "*can be a tool and a detriment at the same time*" (A2 in reaction to EnVisible).

6.5.2. Seeing tracking data causes guilt, anxiety, and "mental anguish" for athletes

Student athletes are already under a lot of pressure and stress from balancing school with training at a high level. D1 describes a "constant push and pull between the two":

> *Being an athlete, so wanting to obviously do well on your sport, get that starting spot that kind of thing. But then also that pull of wanting to do well in school. So like that balance of staying up late studying. But then, you also need to balance that with getting enough sleep, because you want to look good to your coach. And so I just kind of always felt that conflict: like if you're doing that one thing you were giving up on another* (D1 in reaction to EnVisible).

Tracking data can make these decisions more apparent to the athlete, such as sacrificing sleep to study. The behavior changes that the technology is designed to push them towards, such as getting more sleep, might not be possible because student athletes are under a lot of demands for their time.

S1 reflects on how "*cool*" it would be if her team all had Oura Rings, but the demands on student-athletes time might prevent them from doing what the technology suggests:

> *It's hard to get everything that you need as a student-athlete. You need to sleep more, you probably need to eat more. Sometimes time and scheduling doesn't really permit so it's challenging. For some of my student-athletes, knowing that could provide more anxiety for them. You know, 'I didn't get my 8.4 hours of sleep that my ring told me I needed.' I think it could stress them out even more* (S1 in reaction to Clippits).

As S1 suggests, seeing the data might add more anxiety or stress to the already stressful student-athlete life because the student-athlete life prevents them from getting all the sleep or rest that they might need (or that the technology says that they need). This example also represents one way that seeing the data might affect athletes' mental health: underperforming.

Data shows you are underperforming.

A1 and A4 both described how seeing that they are underperforming impacts their mental health. A4 feels guilt towards seeing that she did not meet a goal that was set:

> *I think it has to do with a lot of guilt, like, if you're not hitting the goals that are set for you then you're falling behind, you're not as good...I just feel trapped within the metrics instead of really listening to my body* (A4 in reaction to Clippits).

This feeling of falling behind because you are underperforming is something that A1 also described as frustrating:

> *The biggest thing is like seeing sleep. And it's kind of like self-defeating if you're like dang like I feel like I'm making an effort, but like this is just not...Like I'm really not getting enough sleep and it's frustrating because it just kind of feels like another thing that's like oh man like I'm already struggling with everything else, like now, this like checking the sleep data and seeing that it's not where it needs to be that can be impactful* (A1 in reaction to Clippits).

A1 feels like she is even when she tries to get more sleep, she still falls short so then this becomes another stressor when she might already be struggling.

Fixating on tracking data

Another way that A1 and A4 described being affected by seeing their tracking data was how they would fixate on it. A4 described constantly checking her data to see how she is doing and how that made her feel like the data was controlling her. In addition to constantly checking the data, A1 gave an example of how seeing data that is concerning can send her into an anxiety spiral:

> *But I do know when I see a high resting heart rate I'm like 'oh my gosh' like my mind goes into a little spin like am I sick? Am I starting to get sick? Did I stay up late last night? Was yesterday particularly stressful? So it's a great marker, but I do know for me it does trigger some anxieties around that* (A1 in reaction to Clippits).

A1 acknowledges in this quote that seeing something like a high resting heart rate can be a good indication of potential sickness which can be helpful. However because it does not necessarily mean that something is wrong, it leads A1 to spiral when perhaps there is nothing to worry about.

6.5.3. Discussion: Preferred design and use for tracking technology that supports athlete mental health and wellbeing

Participants' reactions suggest a need for supporting athletes in prioritizing rest, mental health, and overall wellbeing. There were also several avenues suggested for how to support student athletes in prioritizing their wellbeing in the design and use of tracking technology: Coaches, staff or the technology can keep athletes from seeing data or provide education on how athletes should understand and approach using data, and the designers could consider different athletes preferences for or against data in the design.

Support athletes in prioritizing rest, mental health, and wellbeing

In Video #1: Informonocle, the student-athlete hacks the Informonocle so that he can get rest when he needs it or make choices that are good for his physical and mental wellbeing. Though the hacking part of this scenario was not preferred by any of the participants, the conflict the student-athlete faced was a familiar one:

> *What do I prioritize? My personal wellbeing or the training that might be too much? Do I feel comfortable raising concerns that might be too much or do I wait for a coach to tell me you can not do as much as I initially required?* (S2 in reaction to Informonocle).

The ability to prioritize rest and normalizing taking a break was something athletes would want in a preferred future. A2 and A3 both gave examples of how they have been able to do this:

> *I had to rehab from a surgery, and so there's sometimes just that constant monotonous grind of doing all the rehab stuff. And it's like, I just need a little break today... It's just, I need something like, tell the coach "hey, rehab sucked today, can I just take the rest of the day and just relax—basically I just need something to get my mind off of this right now"* (A2 in reaction to Informonocle)

> *I know I've had this moment before where I'm booked with work, I'm so booked—practice is already pushing it, I can't do extra. And I've had times where I will just literally send the coach a message, through whatever messaging platform, and I'm just like "I just can't do this today, I need a break". I've done that a couple times throughout the semester, it's usually nine weeks in or something* (A3 in reaction to Informonocle)

In addition to normalizing taking breaks and prioritizing wellbeing, the tracking technology needs to support this in the design.

D1 pointed out that with the Informonocle "it seems like that athlete is always being connected to the coach" so there is no "sense of downtime when you're always being tracked." She further describes how this design gets in the way of athletes getting rest:

> *So even though you're getting rest, you know in the back of your mind you're being tracked. Like a night's rest or when you're just wanting to chill on the couch and decompress, you always have that 'What am I not doing' or 'I'm not doing something, I'm not living up to my potential.' Like sometimes you need rest and rest is actually more beneficial. So it's that feeling of always being available actually can make you more tired* (D1 in reaction to Informonocle).

Given what D1 describes, athletes need time where they are not "available", where they are able to get some separation from their sport and the feeling as if they are constantly under a microscope. The design and use of both the Informonocle and EnVisible were critiqued for adding a constant presence that gets in the way of getting that space or rest from being always on. S4's reaction to EnVisible stated that this was "dangerous":

> *I think the constant presence like this space where someone goes away from practice away from your dorm room, your bedroom, or whatever is a space you can go to and like, yes, you can access that data. But I don't like that it is constantly present when that future technology is like on the charger. It's constantly projected on the wall, you know, aside from when she's asleep? So, I think that I really don't like that. I think that's dangerous. I think that's unnecessary* (S4 in reaction to EnVisible).

D5 also discussed a related design challenge where in trying to make a technology useful, you might also increase the time and attention that users need to spend with the technology: "*If they have a lot of data at once, like the left side of this scenario, they need to watch the dashboard [more]...so that it also took their time and attention. So there was kind of personally for me a dilemma to design devices that are informative and useful, but at the same time it is harmful for their daily life because we need to make them use the device or the mobile phone frequently*" (D5 in reaction to Clippits).

For D5 this conflict was an ethical dilemma, but this also poses the question of how to create space for the user away from their data while also designing to meet all their needs for using the data.

Avenues for supporting student-athletes with tracking data

The following are three ways that student-athletes could be supported in using tracking technologies to reduce the burden of tracking or the possible impacts on their mental health and wellbeing.

Keep information separate from athletes, so they are not affected

One way to take the burden off of student-athletes and to protect their mental health in regards to seeing tracking data is for the coach, staff, specialists, or the tracking technology to filter the data shared with athletes or prevent them from seeing it at all.

For student-athletes in particular they are already under so much stress as a student and as an athlete, they do not need this added burden. Especially an added burden that might be telling them they need more rest which they just cannot get because they had to prioritize school or because part of training is getting your body to adapt which means working out without getting all the rest that you might need (S4). It does not help athletes to feel guilty when they do not have a choice to make another decision.

S1 expressed her concern that the data can "*get into people's heads to where it becomes more crippling than helping*" (S1 in reaction to Clippits). A concern validated by A1, A3, and A4's reactions to the videos. Though S1 did acknowledge the messages from the video that athletes should be in control of their own data and that they alone are responsible for how much rest they get and how they fuel their body, S1 also suggests that sometimes data is not something athletes ``need *to expend energy on*" (S1 in reaction to EnVisible).

To protect athletes from the added burden of seeing their data, S1 is happy with how her and her staff work together to inform decisions with data so that all the athletes have to do is show up and do the work.

Education and support for mental health around how to approach tracking data

In contrast to S1's perspective, A1 does not think it is enough for a coach to tell an athlete not to worry about the data, she believes "*it's up to an individual athlete and so that's why I think they need support in order to retrain those thoughts around [the difficulty of collecting and looking at the data]*" (A1 in reaction to EnVisible).

A1 thinks that university athletic departments need to do more in training athletes to de-stigmatize mental health and on strategies athletes can use to support their mental health in general as stressed out student-athletes.

We asked A1 whether she has implemented a strategy or anxiety protocol to prevent her from going into an anxiety spiral while looking at her data. Her response was "*I need to implement that!*" Perhaps university athletic departments or the tracking technology companies themselves could be responsible for educating students on these strategies and how to approach data-related anxiety.

This preferred future might be closely tied with Supporting open communication about data (especially between athletes and coaches) and a positive team culture around tracking.

Designing for differences in athlete data preferences

Another way to approach supporting athlete mental health and wellbeing is through the design of technology and finding ways to present data that do not cause guilt, anxiety, or additional stress (or at least do not contribute to it as much).

A4 suggested that technology could present a goal that is tied more to her understanding of her body than hitting a specific number. For example, a goal of running at 80% effort would be preferable because that way she does not "have to think about the numbers" (A4 in reaction to Informonocle). She also suggested having a range when the technology gives a goal for sleep or other measures:

> *I guess my preferences as in like maybe having more of a range so like, like a range for the distance you're going to run or something that's like a goal or like a slightly more of a range for like the sleep you're going to have because like, I don't know, something student*

athletes, like you're going to, you're not going to be able to hit the amount of sleep every night because you have homework and other things like that (A4 in reaction to Clippits).

Designing to present the athlete with a range could alleviate that feeling of falling behind if an athlete is constantly falling short of their sleep goal.

6.6. Reflecting on the value and impact of Speculative Design, Research through Design (RtD) and Discursive Design

This study incorporated multiple methodologies that each informed decisions made and the study outcomes. Researchers and designers who aim to use these methods in their work may benefit from this reflection on how each methodology moved this study forward.

The most impactful decision made was to focus on preferred futures. The term 'preferred futures' comes from Speculative Design and informed the wording of the research question. Also, drawing from Research through Design (RtD), the goal would be that the knowledge created through the design process and embedded in the videos would be preferred futures for the design and use of sports tracking technology. Though we could have designed the videos without this focus, it was a deliberate decision that had a direct impact in creating knowledge that answered the research question: ***What are the college athletic community's preferred futures for the design and use of tracking technology?***

The videos and reactions also created knowledge about possible or probable preferred futures (see Figure 2) that were not preferred. Portraying futures that are probable or possible but not preferred still created knowledge about would be preferred instead and why the probable or possible futures were not preferred.

However, the video that was most successful in generating knowledge about preferred futures was also the only video that successfully portrayed a future that both the research team and those reacting to

the videos thought was preferred. This was Video #3: EnVisible which portrayed the preferred future portrayed of athletes having control over their data and deciding whether or not to share it with their coach, teammates, or others. The option to share or withhold data was not something found in Study 1 which sets it apart as new knowledge created in the design process. Additionally, to my knowledge, this option is not available in any current tracking system, so it pushed those reacting to the video to consider more of what they would want in the future.

The decision to focus on preferred futures also impacted the analysis and presentation of the findings which were organized around identifying preferred futures and why they were preferred.

Another key decision I made was informed by RtD. RtD includes the *field* and *showroom* practices which were purposefully blended together. The design process brought together the implications of Study 1 with perspectives of the research team in the co-design of the videos which represents the creation of new knowledge using the *field* practice and this knowledge was built upon through the knowledge generated by the reactions to the videos in the *showroom* practice. There was so much information to consider across the videos and the reactions that it was difficult at times to draw conclusions. However, RtD emphasizes the creation of knowledge through the design process and in response to the design(s). Therefore, the analysis looked at where reactions to the videos supported or did not support the knowledge created through the design process (and embedded in the videos), and where the reactions created new knowledge beyond what was in the videos.

Last, Discursive Design informed so many decisions in this study, but Tharp and Tharp's facet that recommends defining a message (See Section 5.2.2) was most impactful. The research team had to define a message for each video that included a discourse of competing perspectives and values. Defining a message for each video supported the portrayal of three different discourses, and incorporating competing perspectives and values reinforced the focus of creating discussion rather than the message dictating what the future should bring. The messages also helped define the knowledge that was created

about preferred futures, so we were able to see where reactions to the videos supported each message or added something to it.

This spirit of discussion and competing perspectives also carries the outcomes of this study into the next chapter.

CHAPTER 7

Heuristics for the Design and Use of Personal Data Technologies in Contexts with Complex Social Dynamics

7.1. Motivation: Balancing Individual Versus Team Needs and Goals

Sports teams are a complex social environment with multiple roles with shared goals and conflicting needs. Tracking technologies, in the ways they are currently designed and used, only add to this complexity or reinforce existing tensions. However, tracking technologies also present an opportunity to change current practices and support goals and needs of the different roles on a team.

This chapter will address this opportunity through identifying the core tension that needs to be balanced and presents heuristics that could be used to narrow the *socio-technical gap* (Ackerman, 2000) for the design and use of tracking technologies in college athletics. The ideas I present in this chapter might also be applicable to other contexts with complex social dynamics where personal data technologies are used.

In the sections that follow, I first argue why the core tension that needs to be balanced is the tension between individual goals or needs and team goals or needs. Then I outline what these needs are so that they can be considered. Finally, I present four heuristics that can be used to think through how sports tracking technology should be designed and used in ways that balance the needs of individual athletes and the team. These heuristics are *customization*, *visibility*, *control*, and *legibility* (See Table 8 for a summary).

Customization	**Visibility**	**Control**	**Legibility**
Concerns the ability to *customize* settings for a data type and make decisions including whether a data type should be tracked, what roles can see it, how and when it is shared, and how it is represented.	Concerns how data are represented to different roles.	Concerns how the data flows between roles and giving users *control* of their data or to take action within a system. For example, the ability to opt-in, opt-out, manage, or correct.	Concerns supporting the understanding of how the technology works and educating the users on how the data should and should not be used to avoid misuse and reduce burden.

Table 8. Four heuristics to consider in balancing the needs of the individual and the team in the design and use of tracking technology and data for sports teams.

Based on the knowledge generated from Study 1 and Study 2, the heuristics may offer a path forward that balances tensions between individual and team needs. For example, the tension between supporting individual student-athletes' needs for freedom from surveillance (privacy) and freedom to make decisions (agency) while also supporting the team's need for monitoring athletes could be compromised around sleep data using the four heuristics:

- The design could support *customization* which, in turn, would allow athletes and teams to decide either that they do not want to collect or share sleep data, or that sleep data will be represented in a way that protects an athlete's agency and privacy.
- *Visibility* concerns the method of representing the data in a way that supports these needs. Sleep data could be represented anonymously which supports individual needs for privacy and agency, but still provides coaches useful information about the team's sleep to make decisions or adjust training.
- *Control* would also allow athletes and teams to decide which roles sleep data is shared with and gives student-athletes power to decide to revoke access or to provide more access as their needs

change. If an athlete is struggling to get enough sleep, they might decide they want to share all of their sleep data with a coach or a doctor to get the support they need to get more sleep.

- And *legibility* suggests that tracking technology could support teams in understanding why collecting sleep data is useful and in using it effectively to make decisions about training or to support athletes who need help with time management or medical help.

However, balancing other needs may require further research or discussion to resolve, or may not be resolved at all. For example, the team need for freedom from the burden of tracking (See Section 7.3.2). Meeting this need may not be possible as any interaction with tracking data could be a burden and athletes cannot ignore that they are being tracked. Further, one way to support the individual needs of privacy and agency is to give athletes sole access to and control over their data, but this also adds more burden on the athlete. However, having *customization* in the design such that athletes could turn off different tracking streams may help them get a break. Likewise, no design or use of tracking data can remove the power dynamic between student-athletes and coaches, but considering the *visibility* of tracking data could prevent abuses of power like punishing an athlete for not getting enough sleep.

7.2. Individual Versus Team: Reframing tensions around tracking data

In this section I will argue that all of the tensions surfaced in Study 1 and Study 2 can be distilled to tensions between perspectives, values, needs, and goals represented by an individual athlete versus the team. Supported by findings from Study 1 and Study 2, I will position the needs of agency, privacy, accountability, trust, and surveillance as supporting either individual or team needs, thus putting them in conflict.

Study 1 describes how surveillance is in tension with agency; coaches and staff collect information about athletes but athletes exert agency by distorting their data to manage their coaches' perception of them and to prevent their coach from knowing they did not get enough sleep due to a

decision to study or socialize. I also present *extraction artifacts* and discuss how increased tracking and extraction through tracking technologies may increase surveillance and threaten athletes' agency.

Study 2 builds upon what I learned from Study 1 and provides more information about the tensions I describe in Study 1. The reactions to the videos in Study 2 not only confirmed that athletes' agency is part of a preferred future, but also highlighted athletes' need for (or right to) privacy in connection with agency and in opposition to surveillance or sharing data. However, athletes need for privacy was about their life being their life and having control over their life such that student-athletes' need for privacy becomes more about agency—student-athletes are in constant conflict about what parts of their lives to prioritize (academics, athletics, social life), and they need the ability to make decisions about what to prioritize.

Therefore, increased tracking or sharing of tracking data (if it is not extractive), could "*put restrictions on athletes*" (A1, Study 2) for several reasons I also discussed in Study 2. Athletes were afraid of possible repercussions if their coaches were able to see data that reflected badly upon them such as how little they slept. This could lead to increased stress when student-athletes are already under a lot of stress juggling their conflicting priorities. To avoid repercussions athletes would have to change their behavior. Though this change in behavior might be positive for an athlete's athletic performance, another aspect of their life could be compromised. For example, if an athlete decides to sleep and not study for a test, this could be positive for their athletic performance but impact their academic performance.

I suggest that the needs for agency and privacy are in support of athletes' individual needs and goals. In that case, surveillance, extraction, or sharing of tracking data are in support of the team needs and goals which is mostly represented by the perspective of the coaches and staff through Study 1 and Study 2. Grouping the tensions this way brings the tensions between agency (and privacy) versus surveillance in line with the tension between individual and team goals described in Study 1 and built upon in Study 2.

The reactions to Video #3 EnVisible that I describe in Study 2 discuss how agency and privacy are in support of individual goals while accountability and trust are in support of team goals. Though sharing data had several possible benefits, some of which would support individual goals, sharing data to support accountability and trust between athletes and their coaches and teammates was one of the benefits discussed that would support team goals. Reframing trust together with accountability instead of in tension with accountability is different from what I described in Study 1. In Study 1, I described accountability and trust being in tension when athletes want their coaches to trust them without needing data to hold them accountable or prove they are doing what they need to do. Either way—whether trust and accountability is supported with data or through relationships built between coaches, athletes, and teammates—trust and accountability supports a positive team culture (Jowett & Lavallee, 2007; Poczwardowski et al., 2019), harmonious coordination between roles (Jowett & Cockerill, 2002), and improved team wellbeing and performance.

To summarize, agency and privacy can be considered as representing the student-athletes' perspective and their individual needs, which are in conflict with the team's needs for surveillance, accountability, and trust.

The conflict of perspectives between individual student-athletes and teams exists with or without tracking technology. Study 1 discussed how an injured athlete might risk their own wellbeing by playing through pain due to the desire and pressure to perform well, stay healthy, and prioritize team success. Study 2 discussed how the same desires and pressures could result in athletes allowing their needs for privacy and agency to be compromised by the team's need to collect data to use to improve performance (Karkazis & Fishman, 2017).

The existence of the individual versus team conflict without tracking technology suggests that the fundamental ideas behind these perspectives or the social norms need to be changed if the conflict is to be

reduced. Additionally, the perpetuation of this conflict around tracking technology presents an opportunity for renegotiating the social norms to balance the needs of the individual and the team.

7.3. Individual and Team Needs for Using Tracking Technologies

In pursuit of understanding how to balance the needs of individual student-athletes and the team in the design and use of tracking technologies, it is critical to identify what those needs are.

7.3.1. Individual Needs

These needs are specific to student-athletes and support individual athlete wellbeing. They are also in conflict with team goals and needs because what is best for an individual athletes' wellbeing is not necessarily best for the whole team (see Chapter 4).

Need	**Definition**	**Heuristics and Considerations**
Student-athletes need **freedom from surveillance (privacy)**	• Student-athletes are subject to pressure, scrutiny, and surveillance. They accept that they should be subject to pressure, scrutiny, and surveillance for training sessions and competitions. • Tracking technologies increase the opportunities for surveillance (Karkazis & Fishman, 2017), but having to be always on or having the feeling of always being watched is not something that student-athletes want to add to their lives. Student-athletes need to have time and space where they are able to be free from their coaches gaze and the pressure, security, and surveillance that is part of being a student-athlete. • Student-athletes' need for freedom from surveillance (privacy) is closely tied to	*Customization*, *visibility*, and *control* presented in the next section can help address these questions. • What is the appropriate flow of information in the system that will support this outcome? • What roles should have access to which types of data and at what level of granularity? • Are their types of data that should not be collected?

	their need for freedom to make decisions (agency), freedom from surveillance specifically draws attention to the possible impact that surveillance could have on student-athletes and the student-athlete's need to have time free from surveillance to support their individual wellbeing.	
Student-athletes need **freedom to make decisions (agency)**	● Student-athletes are young adults and college students who, though deeply passionate about their sport, have other concerns like socializing and doing well academically. Student-athletes also sacrifice a lot to take part in their sport and often have to make decisions to put their sport first over other things they might like to do. Though coaches might want their athletes to always put their sport first, student-athletes need the freedom to make decisions like staying up late to study to get a good grade or going out with friends. ● Student-athletes' need for freedom to make decisions (agency) is similar to student-athletes' need for freedom from surveillance, but student-athletes' need for agency specifically draws attention to the academic and social needs of student-athletes and their needs to sometimes make decisions that support their individual wellbeing in some ways, but also put their short term wellbeing and performance at risk. For example, if a student stays up late to study, they will get less sleep which in the short term could impact their wellbeing and performance but in the long term makes them less stressed if studying will support their academic performance.	The heuristics of *customization*, *visibility*, and *control* presented in the next section can help address these questions: ● What is the appropriate flow of information in the system that will support this outcome? ● What roles should have access to which types of data and at what level of granularity? ● Who has control over what information is collected and when it is collected, and what information is shared, when it is shared and how it is shared?

Table 9. A summary of individual student-athlete needs for the use of tracking technology.

7.3.2. Team Needs

Team needs are those that support team goals—improving performance, preventing injury, and rehabilitating injury—and are in conflict with individual needs because what is best for the team may not be what is best for the individual.

These team needs are also represented by the perspectives of multiple roles and may support the needs of one role more than others. For example, the last team need listed in Table 10 is the need for freedom from the burdens of tracking and impacts on mental health. This need originated with tracking data causing student-athletes anxiety as described by participants in Study 2 (Section 6.5). Though supporting this need would support student-athletes individually, it also supports the team. Freeing student athletes from the burdens of tracking and impacts on their mental health supports individual wellbeing and performance which contributes to the team's wellbeing and performance.

Need	**Definition**	**Heuristics and Considerations**
The team needs **trust and accountability**	• Trust and accountability is needed for a healthy team environment (Jowett & Lavallee, 2007). Athletes want their coaches' trust without the coach needing data to prove they are doing what they are supposed to do (Study 1). However, sharing data could support trust between athletes and coaches (Study 1, Study 2) and possibly between teammates. • The team's need for trust and accountability is in conflict with student-athletes' needs for freedom from surveillance and freedom to make decisions, so teams cannot rely on data sharing to promote trust and accountability.	The heuristics of *customization*, *visibility*, and *control* presented in the next section can help address this question. • How to support trust and accountability without sharing all or even any of the data?

The team needs to **monitor athletes**	• Coaches have a lot of expertise in their sport but as they are sometimes relying on gut instinct, they would like to use data to support their decisions (Study 1). • Using data to inform decisions and adjust training or injury rehabilitation supports team goals of improving performance and preventing injuries (Study 1) and is a preferred future (Study 2). • Example of using data to inform decisions: deciding intensity or specific workouts based on how recovered, tired, stressed, or sore the student-athletes are, for example, reducing training intensity if the team is tired and stressed. • Example of using data to adjust training: Heart rate can be used to train in a zone for a particular workout. For example, if the athletes are supposed to train at 65-75% effort, they could use their heart rate while training to adjust the intensity. • Using trends in key data points to inform decisions or make changes in behavior is a preferred future (Study 2).	• How can teams (coaches) collect the data that they need to inform decisions and adjust training while also supporting athletes' needs for freedom from surveillance and freedom to make decisions? • How can design support providing teams (coaches) with usable data and support teams (coaches) in using this data? All four heuristics described in the next section will be useful for addressing these questions.
The team needs to **use data for personalization and learning**	• Designing for and using tracking for personalization and learning is a preferred future (Study 2). • Example of personalization: Heart rate is a personal measurement. Some student-athletes' heart rates will be higher than others while running at the same pace. Rather than use pace to adjust training, heart rate can be used instead to personalize what pace a student-athlete can go while keeping their heart rate within 60-70% of its maximum. This can	The heuristic of *legibility* presented in the next section will be helpful to consider in answering these questions: • How can design support teams (coaches and individuals) with personalized insights? • How can design support teams (coaches and individuals) with learning?

	be an effective way to train (Kiviniemi et al., 2007). ● Example of learning: Through tracking their sleep and how often they use their phone while in bed, athletes might learn that they get 30 minutes less sleep when they use their phone in bed. This might be a useful way to learn that they could get 30 minutes more sleep if they stop using their phone before bed. ● Using data for personalization and learning might seem like an individual need, but coaches and staff in Study 2 stated that tracking technology can be most effective when it can help personalize insights for athletes and help them learn. These uses could be put into action by individual athletes but also in coordination with a coach who could help an athlete learn something using their data. Furthermore, it is not in conflict with the other *team needs*.	● What education is needed for teams, coaches, and individual athletes to learn about personalized insights and to support athletes learning about their bodies?
The team needs a **holistic approach**	● Taking a holistic approach to the design and use of tracking data is a preferred future (Study 2). A holistic approach is preferred because data cannot speak about the subjective and human sides of sports and student-athletes want to be treated as human and as more than their data and the numbers. ● Having open communication around data is another preferred future (Study 2) that could be connected to the need for a holistic approach. Open communication around data could encourage coaches and staff to view athletes as more than their data, and promotes trust that can help	The heuristics of *customization* and *legibility* presented in the next section will be helpful in addressing this need and considering these questions: ● How can design support collecting data types that represent a holistic approach? ● What support is needed for educating teams on a holistic approach and how to support open communication around data?

	ease the tensions between team needs and individual needs. ● Collecting more subjective data and other design features can only go so far in supporting individual and team needs or easing tensions between individual and team needs. Education and support for a holistic approach in how tracking technology is used can bridge the social technical gap.	
The team needs **freedom from the burden of tracking and impacts on mental health**	● Student-athletes have many burdens outside of the additional burden of tracking (Study 2). Tracking data can cause student-athletes more anxiety if they see that they are underperforming, fixated on data, or are overwhelmed by the data (Study 2). ● Protecting student-athletes from the burden of seeing the data and the possible negative impacts of knowing too much was a preferred future (Study 2). ● This need is a team need because it supports team and individual wellbeing. Also, this need is in tension with the individual need of agency. If student-athletes are to be free from the burden of tracking, seeing their data, and the impacts it could have on their mental health, then this could compromise their agency if they do not know what data are being tracked.	The heuristics of *customization*, *control*, and *legibility* presented in the next section will address this need and the question: ● How can the design or use of tracking data protect athletes from the burden or tracking while giving them agency?

Table 10. A summary of the team needs for the use of tracking technology.

7.4. Heuristics for design and use

The four heuristics presented here are *customization, visibility, control, and legibility*. These heuristics crossover both the design and use as it is not possible to separate one from the other. Designers should be able to use these heuristics to create tracking systems that support the use of the systems in ways that negotiate the tensions around the tracking systems and data. Users can use the heuristics to navigate the use of the technology.

Though I will discuss these heuristics in the context of college athletics, they could also apply to other group tracking systems. For example, family tracking (Pina et al., 2017) presents a context with similar tensions to those in the college sports context. Pina et al. describes how privacy was a concern for sleep tracking within families. Children expressed concern that they would not be able to decide to stay up and binge Netflix if their parents would be able to see their sleep data. If, like student-athletes, children need privacy when sharing their data, and, like coaches, parents want to ensure their children are sleeping enough, how can tracking technology be designed to balance these needs? The heuristics of *visibility* and *control* might be useful for answering this question.

7.4.1. Customization

The design should allow teams flexibility to decide which types of data are visible to different roles within the system, how and when each type of data is shared to different roles within the systems, and how each type of data is represented to different roles within the system.

For example, the system could allow a team to decide that heart rate data from practice times is always available to everyone, both coaches and athletes, in real-time and after the fact. The system could also support the team choosing to make the heart rate data be represented anonymously to coaches. And the same decisions would be available for other types of data and the team could make different decisions

for those types. Other examples might include deciding not to collect sleep data, that sleep data is never shared with coaches, or that coaches only get an aggregated representation of sleep (See Table 11).

If the design supports customization, a team's use of tracking technology is not constrained by one design pattern. A team can choose the pattern of data collection and sharing that works for their culture or approach.

Customization necessitates discussions and decisions around what types of data should be collected, when they will be collected, how they will be shared, and so forth. These discussions are what was wanted in a preferred future where coaches, staff, and student-athletes can come together and set expectations and a constructive team culture around tracking data. The worksheet in Section 7.5 lays out questions that teams could discuss and consider, such as what types of data they want to collect, why or why not they should be collected, when they should be collected, and so forth. The worksheet may also help designers identify where customization is needed in the design.

Also, the format of optional data sharing where a student-athlete could either share all types of data collected about them or none creates more tension than a customizable situation where a student-athlete could decide to share their data during training sessions, self-reported data about stress, objective data measuring stress, but not share sleep data. The key point of tension for student-athletes around needing agency and sharing their data seems to be regarding sleep because they are constantly balancing this need for sleep to recover with their need to stay up late to complete academic work. It is possible that athletes are willing to share anything except sleep, which might include a recovery score (e.g., 60% recovered) that takes sleep into account, but does not give a coach any indication that an athlete stayed up until 3am studying.

Furthermore, *customization* could support the need for freedom from the burden of tracking. If student-athletes could turn off a type of tracking data or change how data is represented to them, this could support different personalities that react to data differently. Athletes who like less data could turn

off more data types or have data represented to them more abstractly or as a range. Athletes who love seeing more data could turn on everything that they wanted, but if they started to feel they needed a break they could use customization to get the break from the data.

7.4.2. Visibility

Visibility of data or access to data in a sports tracking system represents power and agency. Study 1 discussed the implications for a system where athletes have limited or no access to their data which reinforces a coach's power. Study 2 opens the door for athletes having access to their data and control over their data, but so long as coaches have full access to athlete data, athletes will not have the freedom from surveillance or the freedom to make their own decisions that they would like.

Athletes' access to their personal data is both another factor limiting their agency in tracking systems and a potential design opportunity to increase athlete agency in tracking systems.

Among the many tracking technologies that exist for use by sports teams, there is variation in who is able to directly access the system and, especially, the data tracked by the system. Associated with this are features (or lack thereof) that facilitate the sharing of data or communication between different users of the system. If athletes do not have access to their personal data, then by default they do not have agency within the system.

Also, if athletes do not have access to their data, then the coaches and staff determine how data is collected, organized, and used. In this situation, athletes do not necessarily know what they are agreeing to and how their data is being used (See Chapter 4). This creates an issue of informed consent. Lack of informed consent could lead to an erosion of trust between athletes and staff. Thus, giving athletes agency and educating athletes about the data is important for developing trust (Karkazis & Fishman, 2017).

Access to the data is in itself knowledge and therefore power, especially compared to having no access to the data. Overall, knowledge is power on both sides (athlete and coach) and, in this case, that is having access to and education about the data and agency in the system. With most technologies already adopted by teams, staff have the most access; for teams that have not yet used technology, the organizational structure and goals would require any investment in technology to be overseen by staff (meaning even if the technology was only meant for athletes to access, somehow the staff would have access too so they know if their investment in the technology is paying off). Staff are already in a position of power, so their omnipotent access in the system could reinforce this power (see Chapter 4).

Additionally, the level of access given to athletes could affect issues of trust, agency, privacy, and surveillance, as well as an athlete's capacity for self-regulated learning. I think of self-regulated learning here as an athlete's ability to turn to themself (Kou et al., 2019) and engage in self-reflection to increase their self-knowledge and therefore power.

The importance of having access to data in the system suggests that *visibility* of data to different roles on the team should be considered carefully. In particular, this heuristic could help check the power dynamics between roles and ensure that everyone is getting what they need without compromising privacy or agency. To do this, I suggest implementing translucence in how data is represented to different roles in a system.

Translucence

Erickson and Kellogg encourage translucence rather than transparency in social or group systems because of the tension between privacy and visibility (Erickson & Kellogg, 2000). Consider a translucent door to a room. This door would allow you to see if people are in the room and if they are close to the door but you would not be able to see the identity of those people or clearly see what they are doing. This supports

visibility and awareness of what is going on inside the room so that you do not open the door quickly and risk injuring someone on the other side. Further, even if you did not care about causing injury, you might be held accountable by seeing that there are other people present who would not like you to cause injury.

A similar concept could be applied to tracking systems. Erickson and Kellogg describe three characteristics of designing for social translucence: visibility, awareness, and accountability (Erickson & Kellogg, 2000). Tracking systems could support the visibility of data to various team roles in ways that give them enough awareness of what the student-athletes are doing or how their bodies are doing to take necessary action, but represent the data in ways that do not reveal the identity of an athlete or specific data points that athletes wish to conceal. In this way, privacy and agency could be supported while also supporting the teams need for monitoring athletes.

Additionally, translucence could support accountability. For example, if sleep data was shared anonymously, athletes could feel comfortable sharing, there would be no need to obfuscate their data, and those seeing the data could trust that it was accurate. This way of sharing could hold athletes accountable to the goal of getting enough sleep knowing that their coach, teammates or someone else would see if someone was not sleeping enough. However, the athlete could still make a decision to put studying before sleep without the fear of their coach or anyone else seeing that it was specifically them that did not get enough sleep. Therefore, translucence could support accountability without compromising trust.

Epstein, Borning, and Fogarty's study of fine-grained sharing also supports the idea of translucence as they consider designing around value tensions that include trust and honesty (Epstein et al., 2013). They found that people did not want to deceive others in sharing because that would violate trust, but a good compromise was found in a design that preserved the big picture while changing the minute details slightly. This compromise is translucent as sharers and recipients of fine-grained data were able to see some data, were aware of the big picture and could hold each other accountable, but some privacy was still preserved.

In this way, translucence might preserve honesty and trust in sharing. There are more complexities in the context of team sports than in the sharing of fine-grained data with family and friends, but I think it is a promising concept for design to build trust and support honest self-reports from athletes.

To my knowledge, none of the tracking systems available today support social translucence because the systems are mostly transparent. Either staff and athletes can see all the data, only staff can, or only athletes can. There are no grey areas or design for translucence. In the next section, I will suggest some possible translucent data representations that designers could consider.

Translucent Data Representations

I suggest four ways that data could be represented with translucence to preserve trust between student-athletes and coaches, allow coaches to use data to inform decisions, and support the needs for freedom of surveillance and freedom to make their own decisions for student athletes.

Anonymity. One way data could be represented to coaches or other staff is anonymously. Consider if a coach is able to see their team's sleep data but it is anonymous. This would allow a coach to see if the whole team is well rested or not, or if it is just a few people that got poor sleep. Seeing this could allow a coach to make a decision like scaling back training or even canceling a training session if they observe a trend of poor sleep during a certain time. Of course, as S1 said in Study 2b, she cannot cancel a game because it is finals week and her team is not sleeping, but if she saw a trend of poor sleep in combination with high levels of fatigue then she could consider doing something to promote recovery for her team.

Aggregation. Another way data could be represented to coaches is as a team average or as a box and whisker plot that shows mean, median, mode, and the lowest and highest data points. Similar to the example for anonymous data, seeing aggregated sleep data for the team could give the coaches some information that they can use to inform their decisions for the team.

Another way to think about representing data as an aggregation is with a score that tries to account for several separate measures. For example, Whoop's or Oura Ring's recovery score combines heart rate variability (HRV) and resting heart rate (RHR) which can both give an indication of how recovered an athlete is or if they are getting sick (Kiviniemi et al., 2007; Mishra et al., 2020) and sleep quality. The algorithms used are proprietary, but it is possible that this score also accounts for trends in the individual measures that it combines. What the user sees is a score from 1% to 100% that indicates how recovered they are on that day. Whether or not measures like these are accurate is a separate discussion (See Section 6.3.5). However, if combined measures like recovery score can be validated, athletes might be more comfortable sharing these measures with coaches or others because they do not show sleep data on its own.

Trend only. In Section 6.3.4, I presented the preferred future of focusing on trends in tracking data because reactions to the videos indicated that trends are more valuable than single data points. Representing data in a trend would be translucent and preferable. However, the trend would need to be a single number that represents a change over a specific number of days rather than a graph that might indicate a value on a specific day. For example, if the information needed to monitor athletes is a trend in the resting heart rate or a trend in their sleep, then a representation of one athletes' data might show that their resting heart rate is up by 10 beats per minute over the past week and their sleep is down by two hours over the past week. This information could be what is needed to know that an athlete is not recovered well or is getting sick. Furthermore, it might be much quicker to draw this conclusion from the trend than from the individual data points.

Alerts. Related to trends, another way data could be represented translucently is through alerts. If the system could detect a significant trend in an athlete's data, then an alert could be sent to anyone of the athlete or team's choosing: the athlete could be alerted or not if they do not want to be burdened, the coach could get an alert if an athlete repeatedly reports feeling sore or tired so that they knew to check in with the athlete, or both the coach and a doctor could get alerts about trends in an athletes' sleep data that

might indicate they are not recovered or need support. There are numerous ways that alerts could be applied and various translucent representations that could be applied in combination with the alert. For example, the alert could provide all the relevant data to the person who is alerted, only the trend to the person who is alerted, or it could provide nothing other than the alert. In the case where nothing is provided other than the alert, the considerations of the next heuristic, *control*, could be applied to really protect the athlete's agency by making it their choice whether to provide more data along with the alert.

These four data representations meet the both needs of the coaches and staff for monitoring athletes and the needs of athletes for freedom from surveillance and give freedom to make their own decisions. Using any of these representations, coaches and staff could have the information, like sleep, that they need for making decisions about training, and athletes could feel comfortable sharing even when they stay up until 3 am studying for a test. And, importantly, these data representations should remove the need for athletes to obfuscate their data. Obfuscation resulting in false data benefits neither the athletes nor the team as: 1) Athletes need to put in effort to obfuscation strategies, 2) If coaches are making decisions based on false data, this could be harmful, and 3) Obfuscation erodes trust.

These representations do leave the question of what should be done when an athlete might need some help or intervention from a staff member if, for example, they are consistently sleeping badly. The heuristic of *control* offers an answer to this question.

7.4.3. Control

This heuristic is concerned with how information should flow between different roles on a team. Study 1 described how information currently flows in coordinations around tracking data. These current flows of information had tensions around them, so Study 2 investigated preferred futures that might balance these

tensions in managing tracking data. The key tension for managing tracking data is between athletes sharing data with coaches to meet team needs and athletes' needs for privacy and agency.

However, as Nissenbaum suggests, the idea that control over personal data is privacy should be rejected and privacy should instead be thought of as *contextual integrity* where privacy is dependent on the norms of the context that determine *appropriate flow of information* (Nissenbaum, 2004).

I suggest three ways to consider appropriate flow of information in sports tracking technologies for college athletics: agency, negotiability, and distribution.

Agency

Agency is concerned with giving users—in this context, student-athletes—control over their personal tracking data or to take action within a system. For example, the ability to opt-in, opt-out, and manage or correct data (Mortier et al., 2014). Having agency in tracking systems is a core need for student-athletes because they need the ability to make decisions to support their academic success that conflict with their athletic success.

Student-athletes lack agency overall compared to professional athletes who have agents that work on their contracts and players associations that have power to bargain with a league. The norm of surveilling athletes and organizational coercion limits athletes' ability to opt-out (See Section 6.4.5), and the current design of tracking technologies does not give athletes power to act within the system to control, manage, or correct their data (See Section 4.6). This lack of agency could result in student-athletes employing strategies of obfuscation (Brunton & Nissenbaum, 2015) which could render the data unusable.

Student-athletes should be able to determine *if, when, how, and with whom* their tracking data is shared. Table 11 describes *how* student-athletes might be able to choose to share their data with other roles and how they might choose to or be able to see their data or their teammates data.

	Coaches (and Staff)	Athletes
All Data	Coaches have access to all the data collected about all their athletes	Athletes have access to all their data and their teammates data
Anonymized Data	Coaches have access to all their athletes data but it is anonymized (e.g., Someone got only three hours of sleep, but who?)	Athletes have access to all their own data and their teammates data but their teammates data is anonymized.
Abstracted Data	Coaches have access to athletes data but it has been aggregated (e.g., average hours of sleep for the whole team) or is abstracted so the information is more subjective (e.g., sleep quality instead of hours of sleep).	Athletes have access to all their own data and an abstracted view of their teammates data.
Trend only	Coaches can see trends in athletes data but not data points for a specific day. For example, a coach could see that over the last two weeks that an athlete has gotten less sleep than the previous two weeks.	Athletes can only see trends in their own data.
Alerts	The system can alert coaches or staff if a student-athlete has a trend in their data that needs attention, but otherwise they will not be able to see the athletes' data. Athletes can opt-in to these alerts or not.	The system alerts athletes if they have a trend in their data that needs attention, but otherwise they will not be able to see that type of data.
Own Data	Not applicable.	Athletes have access to their own data but not their teammates data.
No Data	Coaches and staff do not have access to any individual or team data.	Athletes do not have access to their own data or anyone else's.

Table 11. Examples of controls that could be used for how data is shared to different roles. An entire team could decide that all data will be shared with coaches and staff but it will be anonymous. Or, individual athletes could decide that they only feel comfortable sharing trends in their data with coaches. Athletes could also decide to hide their data from themselves except they want the system to alert them if there is a trend in their data that needs their attention.

Also, Table 11 describes the possible *how's* for sharing data in a way that assumes once the sharing mechanism is chosen, the data is shared this way automatically. However, there could be additional controls for *when* data is shared such that a student-athlete could decide to automatically share their sleep data anonymously or choose to need to approve sending their sleep data every time.

Building on the previous heuristics, teams should be able to *customize* these data flows for each type of data and role with whom data is being shared. The options for *how* data might flow in a system also build off of the data representations described for *visibility*. *Control* and *visibility* overlap on the question with whom tracking data is shared, in other words, who has access to a data type. The distinction between *visibility* and *control* is that *visibility* concerns how to represent the data and *control* concerns the ability to choose how the data is represented to a different role within the tracking system.

Negotiability

Negotiability is concerned with the social dynamics around data collection and use, and giving users the ability to change decisions about their data given a certain situation or changing social norms (Mortier et al., 2014). I borrow the term negotiability from Mortier et al., who propose a framework for human-data interaction. However, using tracking data in college athletics might best be described as human-data-human interaction.

When data is shared from any user to another user, especially when student athletes are sharing data, the user should be able to change their minds about sharing at any time, even after the data has been shared. This concept might also be thought of as revertability. If a student-athlete shares a type of data with their coach, the tracking system should allow them to revert this choice so that the coach would no longer be able to see these data.

Distribution

Distribution is concerned with figuring out how data might be distributed across roles. This was a preferred future described in Study 2 where data might be shared with others according to their specialty. Beyond athletes having the agency to decide *with whom* they will share the data, sports teams will also need to decide if certain roles should not be able to receive certain types of data. For example, a team could decide that a coach should not receive sleep data at all, and that sleep data should be the responsibility of another role or a specialist.

7.4.5. Legibility

This heuristic is concerned with making the data themselves, algorithms, or other uses of the data transparent and understandable to users interacting with a system (Mortier et al., 2014).

As I discussed in Section 6.3, student-athletes, coaches, and staff need to be able to interpret data properly to use data in their preferred ways. For example, I have previously mentioned how heart rate variability (HRV) is a measurement that both Whoop and Oura Ring provide their users, and that HRV can be used to manage an athlete's training on an individual day-to-day basis (Kiviniemi et al., 2007). Supporting *legibility* in regards to HRV could involve providing education on the measurement itself, how it is calculated by the tracking technology being used, and how HRV can or cannot be used in the sports context. Additionally, this education would need to be free of jargon and designed to be understandable to those without degrees in medicine, kinesiology, or physiology.

Understanding the data themselves and how they can or cannot be used is useful for balancing the needs of individuals and the team. For instance, if a data type is going to be collected, then all those involved should be able to provide reasoning as to why that data type should be collected and how it will be used. Legibility might also help teams decide not to track a certain type of data if they are not able to make use of it.

Both designers and sports teams should consider how to support *legibility*. Designers could consider how to build educational content into their design, student-athletes could be provided supplementary educational content, or a specialist could support teams in making use of the data and the products. Teams could also seek out educational content on their own.

A key point of focus for *legibility* should be how the data should or should not be used. This could prevent misunderstanding and possible misuse, and facilitate positive team culture around tracking data.

7.5. Worksheet for both designers and teams

This section describes a worksheet that I developed to help work through all the considerations for data collection, sharing, and use around different data types. Both designers and teams could use this worksheet differently. Designers could use this worksheet to think through what is needed to support the needs and nuanced social dynamics of teams. And college sports teams, athletic departments, or other sports organizations could use this to help determine how they will use tracking technology. However, some options for this worksheet might only be possible if the design supports it. For example, a team cannot choose to have an anonymous representation of sleep data if the design does not support it.

The heuristics in the previous section are also represented in this worksheet. Most of the questions in the worksheet represent an opportunity for *customization* in the design or use of tracking technology. For example, which data to collect or not, when to collect each data type, with whom each data type is shared, and how each data type is represented to the people that it is shared with. Designers could use the worksheet to figure out what customization options are needed, and then teams could use the worksheet to decide how they will *customize* their use of the tracking system. Researchers could also use the worksheet to figure out how teams want to *customize* their experience and then use this to inform the design.

Similar to *customization*, a number of questions in the worksheet concern *control*. The worksheet prompts designers and users to think about *if, when, how, and with whom* data should be shared. Designers should consider how to offer control over these aspects to different users, particularly student-athletes. Teams can use the worksheet to consider who should have control over these aspects within data types, if one role should control everything for a particular data type, or if one role should have control over everything for all data types.

The questions about data type representation and if a data type should be shared with a specific role concern *visibility.* Designers could use these questions in combination with Table 11 to figure out

how to represent different data types in a way that is anonymous, aggregated, trend only, or another representation that might work for a specific data type. Teams can use the worksheet in combination with Table 11 to decide which representation they want to use. Additionally, researchers could explore what data representations teams like the best or what is preferred for different data types.

Lastly, questions that ask 'why' concern *legibility* because they involve understanding how data is collected, how it could be used, why it should or should not be used, and what is to be gained or lost by sharing the data with different roles. Designers could use these questions in the worksheet to figure out what education or support could be useful to provide. Teams could use these questions to determine what knowledge they are lacking and seek to educate themselves to fill in the gaps.

I have filled the worksheet example below for two types of tracking data: heart rate during training sessions and sleep data. The responses to the questions for each data type are based on what I have learned in the course of my research. The responses that have a full paragraph or two as an answer to the question in the left column are based on everything learned in Study 1 and Study 2.

However, there are numerous responses that include question marks. Most of these represent choices based on those I presented in the previous sections (Section 7.4), such as choices for how data should be represented. I did not provide a definitive choice in those cases because the heuristics are untested, so the list of choices is intended to represent the further discussion or research that is necessary. Also, I did not provide a definitive yes or no as to whether each data type should be collected. This question of whether a data type should be collected at all is aimed at teams. My intent is for teams to discuss the rest of the worksheet first before making this decision. The questions should help teams discuss if the reasons for collecting a type of data outweigh the reasons not to collect it. Additionally, teams could discuss which options for sharing a data type would make them comfortable. If none of the options would meet everyone's needs, then the team could consider not collecting that data type. Such a

discussion might also benefit designers' understanding of where further *customization*, options for *visibility* and *control*, and *legibility* are needed.

Also, the worksheet only considers sharing between student-athletes and coaches. It should be extended to include other roles, such as athletic trainers, strength and conditioning coaches, team psychiatrists, team doctors, academic advisors, and athletic directors.

	Example Data Types	
Questions to consider	**Heart rate data**	**Sleep**
Collect at all? *Customization in the design would afford customization for each team about whether or not to collect this data type at all.*	Yes or no?	Yes or no?
How is this data type collected? *Understanding how this data type is collected may influence the answers to the rest of the questions.*	Chest-worn device that collects heart rate data using photoplethysmography (Castaneda et al., 2018)	This data type is available through an algorithm that combines heart rate data, accelerometers, and blood oxygen.
When to collect this data type? *Deciding when to collect a data type could influence the answers to the rest of the questions.*	Collect this only during practice.	At night.
Why collect this data type? *Considering why to collect a data type could help designers with making the data usable and help teams decide whether or not they want to collect this data type.*	Collecting heart rate during training sessions will give the training load of each athlete which can be used to adjust the training for each individual athlete or the team depending on the cumulative load from a practice/competition or more likely over the last few practices/competitions. If load becomes too high over a period, athletes are at risk of injury.	Sleep has a huge impact on performance. Multiple participants have referred to it as the number one determining factor in performance. Though coaches cannot control this and student-athletes have other concerns like school that can get in the way of sleep, coaches or staff could intervene if sleep became a recurring trend for a student athlete. They might also adjust practice if the team slept badly for a week during midterms/finals, etc.
Why NOT collect this data	There are a few reasons not to collect	Participants in Study 2 spoke to the

	Example Data Types	
Questions to consider	**Heart rate data**	**Sleep**
type? *Considering why a data type should not be collected could help teams decide whether or not they want to collect this data type.*	HR in practice but if there were any type of data to collect, this would be it. It is collected during practice time so it is fair game in the athletes minds and the coaches need it to determine how difficult practice was or help athletes push to the best of their ability. There are a few cautions like making sure this doesn't affect the student-athlete and making sure the data is accurate and the coach can get value out of it, but if these things can be achieved, there is no reason not to collect.	idea that though sleep is important, it is possible to get very little sleep and still perform well. The reverse is possible as are other situations, so a trend of consistently bad sleep would be more concerning. That said, is it worth subjecting student-athletes to an additional stressor/cause of anxiety (seeing their sleep data) and worth the complications and possible consequences of this data being shared around?
Share this data type with the student-athlete? *This question concerns Visibility and Control.*	Athletes do not necessarily need to see this data if the data will be used by the coaching staff to inform decisions (Study 2). If heart rate is being used to determine how hard an athlete is pushing during training, then the athlete would need to see this data (Study 2). Additionally, coaches might want to use this data to help athletes with their training (Study 1).	Student-athletes should have access to their own data and could use their sleep data to learn about their sleep habits and improve their sleep. However, some athletes may not want to see their sleep data as they may feel like they are constantly not getting enough sleep.
WHEN to share this data type with the student athlete? *This question concerns Control.*	The following represent options that designers or teams could consider: Always? (athlete has access to all HR data) During practice (real time) After practice? Another time? Never?	The following represent options that designers or teams could consider: Always? Never? Only when the system detects they are sleeping very poorly?
Who DECIDES when this data type is shared with the student athlete? *This question concerns Control.*	The following represent options that designers or teams could consider: Athlete? Coach?	The following represent options that designers or teams could consider: Athlete? Coach?
WHY share this data type with	This could help athletes understand	Understand their sleep patterns, see

	Example Data Types	
Questions to consider	**Heart rate data**	**Sleep**
the student athlete? *This question concerns Legibility.*	and manage their own effort (data as a tool for learning).	the effect good and bad sleep has on their performance, and make informed decisions about sleep.
WHY NOT share this data type with the student athlete? *This question concerns Legibility.*	Student athletes already have a lot on their plates, bad heart rate data could "get in their head", cause more anxiety about their health and wellbeing.	Student-athletes are already under a great deal of stress. Sleep is one of the things often sacrificed to either get school work done or socialize so bringing the effects of that to their attention may not be productive. Student-athletes deserve to make their own choices and have their own priorities outside the team.
If so, how should this data type be REPRESENTED to the student-athlete? *This question concerns Visibility.*	The following represent options that designers or teams could consider (also see Table 11): Aggregated: Average HR? All data: HR graph for the whole day?	The following represent options that designers or teams could consider (also see Table 11): Anonymized: Hours of sleep? Abstracted: Quality of sleep? Alert: Let the student-athlete know if they have been sleeping poorly for an extended period of time?
Share this data type with the coach? *This question concerns Visibility and Control.*	Yes or no?	Yes or no?
WHEN to share this data type with the coach? *This question concerns Control.*	The following represent options that designers or teams could consider: Always? (coach can always see HR data) During practice? (real time) After practice? Another time? Never?	The following represent options that designers or teams could consider: Always? Never?
Who DECIDES when this data type is shared with the coach? *This question concerns Control.*	The following represent options that designers or teams could consider: Athlete? Coach?	The following represent options that designers or teams could consider: Athlete? Coach?
WHY share this data type with the coach?	Sharing heart rate data during training sessions is normal for a college sports team. Additionally, the coach can	The coach can adjust training based on sleep to protect athletes against overtraining and fatigue. Also, if an

	Example Data Types	
Questions to consider	**Heart rate data**	**Sleep**
This question concerns Legibility.	adjust training for each athlete to protect athletes against injury.	athlete is sleeping poorly, the coach could support an athlete in addressing the problem.
WHY NOT share this data type with the coach? *This question concerns Legibility.*	Athletes may not want to share their heart rate data with the coach, especially if the coach is not educated in how much heart rate can differ between people.	Athletes may feel uncomfortable sharing data from off-time with the coach, especially sleep data because athletes fear judgment from their coach if they did not get enough sleep.
If sharing this data type with the coach, how should the data be REPRESENTED? *This question concerns Visibility.*	The following represent options that designers or teams could consider (See Table 11): Anonymous? Aggregated? (team avg) Trend only? Alerts only?	The following represent options that designers or teams could consider (See Table 11): Anonymous? Aggregated? (team avg) Trend only? Alerts only?

Table 12. Example of a worksheet that designers and teams could use to figure out where to apply the heuristics described in this chapter.

7.6. Further considerations for after these heuristics are implemented

The worksheet in the previous section (Table 12) represents how I would approach the design for and use of two types of data by applying the four heuristics to what I have learned in my work. Though this approach would be an important step in balancing the needs of individual athletes and the team, there will be more to figure out after these heuristics and other recommendations suggested in this dissertation are applied.

One question is how to design for negotiation. A major part of my recommendation in this chapter is for teams to discuss and make decisions together for how to customize their use of tracking systems. However, the power dynamics described in Chapter 4 do not disappear because the design provides new options that offer a restraint of that power. The team dynamic is set both by the athletes and the coaches, but the coaches can have a strong impact on that dynamic if they approach the team as a dictatorship instead of encouraging communication and collaboration.

Teams too can bring peer pressure and be as coercive as the pressures from coaches and staff which are another factor that could impact the specific preferences of an individual athlete for how they want to use tracking systems.

Teams, particularly the coaches and staff, will need to be open to discussing how tracking technology should be used if the heuristics are to work as intended. Additionally, many of the other recommendations I make in this dissertation require open communication between all roles on a team.

Researchers, designers, and teams should be prepared for further work to figure out how to give athletes negotiating power or how to support team discussions with negotiation between athletes and staff. Related to this are the recommendations I left open-ended regarding how to provide education to teams about tracking data and its use. Crafting this education will be closely linked to the use of tracking technologies going well after designers apply the heuristics and other recommendations in this dissertation.

Though future work should evaluate the effects of applying these heuristics, I anticipate their use will focus the efforts of designers, researchers, student-athletes, coaches, team staff, and NCAA policymakers in improving the design and use of personal data technologies in collegiate athletic teams. Further, if application of these heuristics addresses the highest priority needs identified in this dissertation, it is likely that other needs and opportunities to improve will become visible, and so future work may expand on or refine the heuristics proposed here.

CHAPTER 8

Conclusion

At the start of my dissertation I quoted a statement from a participant in the Luczak et al.'s study of how strength and conditioning coaches and athletic trainers currently use tracking technology: *"Wearables are fool's gold.*" In conducting my research and writing this dissertation, I have thought about the use of wearable technology in college athletics in every which way. This includes thinking that they may be fool's gold which resulted in the critical approach I took in Study 2.

I consider myself a technologist, someone who loves and believes in technology, but I am also of a second mind, one that would love a somewhat simpler existence with freedom from the technologies that have taken control of society and sometimes my life. I recently read an argument by Chris Kelty that he titled "The Fog of Freedom" (Kelty, 2014). Kelty says that technologies such as the personal computer were designed to enhance human capabilities, to give humans the "freedom to" do more, however, this freedom might be a trap. In the fog of freedom, the freedom we are promised can be reimagined as coercing us into using these technologies and these information technologies may interfere with our goals and bring us under other spheres of control or coercion. Despite my lived experience and all I have studied telling me that this is true, I have not thrown out my phone, my computer, and my wearable device, nor have I deleted any of my social media or other online accounts.

I have not taken these actions because I know that information technologies are not going anywhere. I am also still inclined to believe in technology and the potential for good.

In the context of my dissertation, the fog of freedom is what led to the thinking that wearables may be fool's gold. Wearables, like other information technologies, offer many freedoms. For athletes, wearables could mean freedom from a coach's influence, freedom to learn about their bodies, improve, and make decisions about their training with or without the help of a coach. For coaches, wearables could

mean freedom from making decisions based on their gut instinct and freedom to use data to help them make decisions that could make their team better and protect their athletes from injury. Whether these freedoms are good is up for debate.[26] The promise of these freedoms has led (or coerced) individual athletes and teams (via coach or athletic administration decision) to adopt wearable technology. And in adopting these technologies, athletes, coaches, and other staff are subjected to different forms of control and coercion. The user, whether it be coach, staff, or athlete, can be influenced by the data mentally and in their decision making. The technology can also bring the athlete further under the influence of the coach and/or staff. Ultimately these influences may interfere with the goals or needs of these users.

However, the adoption of these technologies is not going to be stopped and they have great potential to help athletes, coaches, and staff achieve their goals rather than interfering with their goals. And so my dissertation has taken a critical approach to the promises of wearable tracking technology.

I have examined how the adoption of wearable technology is disrupting interpersonal coordination to achieve the goals of athletic teams, the tensions this disruption causes, and how that disruption can reinforce power dynamics in college athletics or could be an opportunity to change current practices and better support coordination between roles on college athletics teams. I have also looked into the future to identify preferred futures for the design and use of tracking technology. This speculative approach has shown that designers and users of sports tracking technologies should focus on data interpretation and use, management of tracking data, and supporting athlete mental health.

Lastly, I synthesized the findings from my work and argued that the core tension that needs to be balanced in the design and use of tracking technology is the tensions between individual student-athlete needs and the needs of the team. I identified the specific needs based on my findings from Study 1 and

[26] Coaches exist for a reason. They provide an external perspective and expertise that athletes can benefit from. And this same expertise should not be discounted in decision making.

Study 2 and recommended four heuristics for considering how to balance these needs: *customization, visibility, control,* and *legibility.*

I hope that these contributions can be applied to the design and use of personal tracking technologies in college sports and other levels of sports, and the design and research of personal tracking technologies in other contexts.

8.1. Implications & Future Work

In this section I briefly summarize the implications of this dissertation for student-athletes, college athletics staff, designers, and researchers. I also propose future research where my findings or approach could be applied in other contexts and further research in the context of tracking technologies in sports.

8.1.1. Implications for student-athletes, college athletics staff, and designers

Student-athletes are young, 18 to 22 years old, who may be far from their families for the first time. They face pressure to perform athletically and academically and a constant push and pull to make decisions to prioritize athletics or academics. Given the circumstances of student-athletes, coaches and staff may take an almost parental role in relation to student-athletes. Unlike parents however, a coach or staff member is responsible for creating the best team possible and so they cannot be a parent to every athlete and they must also view each student-athlete as a resource.

Student-athletes may not recognize the unique position and power that coaches or other staff have in their relationship. Several student-athletes in Study 2 expressed an attitude of "if coach said do it, I'll do it," meaning that they trust their coach and may do whatever is asked to them, possibly without question.

In considering how tracking technologies *should be* designed for and used by college sports teams, both college athletics staff and designers need to recognize the power dynamics and unique circumstances of student-athletes. Coaches and staff can be wonderful mentors and supporters of student-athletes and tracking technology can facilitate these relationships and be a resource for student-athletes and their teams, but not if coaches, staff, and designers lose sight of the student-athletes.

8.1.2. Implications for researchers and future work

The heuristics presented in Chapter 7 and the contributions from my dissertation can apply beyond college athletics to the collection and use of personal data in other athletic organizations, in health care settings, in schools, and in the workplace. Most alarming and likely applicable to any reader of this dissertation is employee productivity tracking (Kantor et al., 2022). The power dynamic of the employee-employer relationship is similar to that of the athlete and coach. A New York Times article describes how employers are extracting productivity data from their employees which reduces their agency to do things as simple as taking a bathroom break (Kantor et al., 2022). Like sports tracking technologies, these productivity trackers also fail to capture the human experience with a holistic approach of productivity. And though tracking productivity represents accountability, the result is an erosion of trust.

Other notable context examples are family tracking (Pina et al., 2017), the use of GPS to track delivery and long-haul truck drivers (Apostolopoulos et al., 2014; Roetting et al., 2003), the use of police body cameras (Coudert et al., 2015) intended to disrupt long-standing power asymmetries that have favored police, and tracking of college student attendance (Harwell, 2019) and engagement with course platforms (Romano, 2021).

Researchers conducting work in these contexts might consider applying a similar approach or part of the approach I have applied in college athletics including identifying boundary negotiating artifacts,

tensions between stakeholders in their context, the needs of these stakeholders, and what should be considered to balance the needs of the stakeholders. It is possible that the heuristics I present in Chapter 7, could apply to these contexts too. Researchers could evaluate these heuristics in these other contexts where personal data and tracking devices are used.

Researchers could also consider expanding this work in sports. The two studies presented in this dissertation are just the beginning of what could be a lifetime's worth of research in the context of collaboration around and design for tracking technology in college or other levels of sports. I did not set out to definitively answer questions like: *What should tracking technology look like? What data should it collect? How should that data be collected? When should data be collected? With whom should collected data be shared and how (what form would it take)? How should the data be used?*

Answering those questions and identifying more specifics for preferred futures for the design and use of tracking technologies on college sports teams could be approached in many different ways and with different scopes:

- Study 2b proposes numerous preferred futures which could all individually be investigated in their own study. For example, a study could be designed to evaluate new designs for tracking technologies that forefront trends or investigate use cases for how data can augment coaches' powers of observation.

- How design can support data management that meets athletes needs for agency and privacy while also addressing needs for sharing the data with coaches is still a complicated problem that needs further input from college teams that are currently using platforms that track data 24/7 like Oura Ring and Whoop.

- The area of supporting student-athletes mental health is another area discussed in Chapter 6 and could be its own separate area for study. Designing for mental health interventions is already a huge area of study in HCI and psychiatry (Arean et al., 2016), but student-athletes are in need of mental health support and might be willing to engage in these studies as they used to being tracked and having to talk to coaches about how they are doing and how to make behavior changes and overcome obstacles.

- The heuristics presented in Chapter 7 could be evaluated in a future study. They could be used to structure interviews, focus groups, workshops, or even another set of videos that aims to present more desirable preferred futures. The heuristics could also be used to develop and test new designs for tracking technologies such as the anonymous or aggregate data representations.

- The worksheet presented in Chapter 7 could be used to structure workshops or focus groups around the design and use of sports tracking technology.

- Study 1 deliberately involves different staff roles other than a coach, but Study 2 needed to scope down to reduce some complexity so there are also questions about the preferred futures for staff collaboration around data, how different staff members hope to use data in the future, and how the data should be shared to different staff members.

8.2. Concluding Remarks

In the end, with all the complicated tensions, it would be reasonable to ask: Why share data? The athlete in me has struggled to articulate the need for sharing data, especially between student-athletes and coaches. If the answer is, “that’s just how it is,” then this dissertation would not exist. Sports teams naturally rely on coordination and the success of the team is mutually dependent on each role being able to get what they need to do their job. Sharing tracking data is part of coordination and what they need to do their jobs.

Tracking technology represents an opportunity for sports teams to rethink and redesign how coordination and sharing of data happens between roles to support and balance the needs of these roles to help teams work more effectively toward their goals in the process. I set out to approach this opportunity through two aims: understanding how tracking data should be collected and used within college athletic teams, and how designers and practitioners should balance the tensions between the goals and needs of different roles (e.g., student-athletes, coaches, and athletic trainers) around tracking data.

I have found that college sports teams collect athlete information and coordinate around athlete data with and without tracking technology. Current data collection practices are extractive and studying coordination between team roles around athlete data reveals power dynamics between team roles and tensions between the needs of different team roles. Tracking technologies are disrupting current practices but the current design of tracking technologies is only reinforcing extractive data collection, power dynamics, and tensions in addition to threats to athlete privacy and agency.

However, the disruption of current practices by tracking technologies also presents an opportunity for change. Designers and users of sports tracking technology should consider how tracking technology could support data collection in ways that are not extractive, facilitation of coordination between roles, athletes needs for privacy and agency, augmentation of human expertise, personalized insights, and decisions based on trends in data.

Furthermore, designers and users of sports tracking technology should also consider how to balance the goals of the team and the individual which presents many challenges to coordination and use of tracking data with and without technology. To promote design and use of tracking data that balances the goals of the team and individual roles, designers and practitioners can consider *customization*, *visibility*, *information flow*, and *legibility* in the design and use tracking technologies to support individual and team needs without compromising one of those needs.

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APPENDIX

I. Athlete Tracking Research Group Artifacts (Study 1)

Accompanying artifacts and information about the research group that contributed to Study 1.

A. Advertisement Recruiting Students for the Research Group

Title: HCDE 496/596 (Fall 2017): Exploring the Use of Wearables in Competitive Athletics

How can wearable technology (Catapult Sports, Zebra, Zephyr, Fitbit, etc.) be used to improve athletic performance? Prevent injuries? What challenges do wearables and related technologies pose to college athletics? We define wearable technology in this context as any type of sensor worn on an athlete's body—e.g. a watch, chest strap, sensor built into a shoe, or a screen worn on an athlete's shirt. In this research group, we will learn and practice qualitative research methods (for example, interviewing, interpretive analysis, and value-sensitive design) to better understand the opportunities and challenges related to the use of wearable technologies within competitive athletics. We hope to assemble a diverse team that includes students trained in HCDE methods as well as "subject matter experts" who have experience with competitive athletics, including UW student athletes.

This course can be taken for 2 credits (~2 hours of classroom meeting time + 4 hours of additional work each week).

If you are interested in applying to join this Directed Research Group, please send a (short) resume plus an email message or cover letter telling us why you want to be involved and how your hope to contribute. Please address these materials to Sam Kolovson at kolovson@uw.edu.

B. Research Group Roster

Student-athletes	**HCDE Students**
Sam Goetz, Men's Rowing	Natty Solomon, HCDE BS
Zoe Schaefer, Women's Gymnastics	Erica Dillman, HCDE MS
Imani Apostol, Women's Track and Field	Ivy Kehoe, HCDE BS
Fred Huxham, Men's Track and Field	Ben Powell Wagner-Wilkins, HCDE BS
Brandon Maurice Lewis, Football	Melody Yu, HCDE BS
	Valerie Huang, HCDE BS

C. Fall 2017 Research Group Syllabus

Wearables in College Athletics DRG

Meetings: Tuesday 7-8:30pm in Sieg 420

PhD Student: Sam Kolovson, kolovson@uw.edu
Faculty: Kate Starbird, Sean Munson, David McDonald

Course Aims:

- Students should gain experience in a variety of research methods
- Students should feel that they made a research contribution (poster)

Week (Meeting Date): Topic	**To do by next meeting**
Week 1 (10/3): Introduction	Read Week 1 readings
Week 2 (10/10): Research Question Discussion	Read about interviews and add one question to the interview protocol
Week 3 (10/17): Interview Protocol	Schedule 2-3, 60 minutes interviews for 10/25-11/7
Week 4 (10/24): Interview Techniques	Have done at least one interview by next meeting (10/31)
Week 5 (10/31): Memoing	Have done interviews two and three by next meeting
Week 6 (11/7): Transcription	Transcribe at least one interview
Week 7 (11/14): Analysis	Start poster
Week 8 (11/21): No meeting	Happy Thanksgiving!
Week 9 (11/28): Analysis	Finish poster
Week 10 (12/5): Poster	Done!

In week 3, students will divide into pairs of one student-athlete with one HCDE student. Each pair conducts at least 2, ideally 3 interviews of athletes (total of 15 interviews). Every person must be the main interviewer on at least 1 interview.

Note: Everything subject to change.

II. Speculative Futures Research Group Artifacts (Study 2a)

Accompanying artifacts and information about the research group that contributed to Study 2a.

A. Advertisement Recruiting Students for the Research Group

The following is the advertisement used to recruit design students to work on Study 2a. A similar advertisement was used to recruit the student-athletes but the section about 'Who' I was looking for was adjusted to say that I was looking for junior and senior student-athletes and no specific qualifications were necessary.

DRG: Speculating the Future of Sports Technology (Winter-Spring 2021)

Led by

- Sam Kolovson, PhD student, HCDE
  - kolovson@uw.edu
  - *Contact Sam with questions, issues, and concerns.*
- With guidance from faculty advisors, Sean Munson and Kate Starbird (both HCDE professors) and input and critique from other students and faculty with relevant experience.

Who

- Seeking 4-6 HCDE/Art/Design students who will work with Sam and six student-athletes.
- Open to BS, MS, or PhD students.
- Preferred experience: We are looking for students with experience with design, art, storytelling, cinematography, and/or video editing.

What

We will create three short videos to provoke discussion around the future of tracking and data collection in sports. Through a research method called Speculative Design we will aim to get student-athletes, coaches, and staff at universities in the US as well as the wider collegiate athletic community to think about what they want (or don't want) from sports tracking technologies.

Videos might raise questions such as:

- *Should coaches have access to their athletes' sleep data?*
- *Should we design a device to collect a detailed caloric breakdown of every meal an athlete eats?*
- *What about swallowing or installing a sensor underneath an athlete's skin to track exertion? Or hydration?*

Examples

- An example of a video we might create is this project titled "Uninvited Guests" that is intended to provoke reflection and discussion about whether using tracking devices for remote health monitoring: http://superflux.in/index.php/work/uninvited-guests/#
- A pop culture example of the narrative we might strive for is the movie *Her*.

What students will do
Throughout the duration of the DRG, students will be introduced to relevant research methods and design skills read through literature, films, and other media. We may also discuss proper execution of these methods and skills during our meetings.

- *Winter 2021*: Students will be directly involved with developing original ideas, creating storyboards (narratives for the videos), and designing possible futuristic technology prototypes to appear in the videos.

- *Spring 2021*: Working in teams, students will develop the script for the videos, recruit actors, plan out how to create the videos, and shoot the videos (ideally, in-person, socially distanced, but we will adjust our plans for COVID-19 safety).

Expectations/Commitment

- Participate in winter and spring quarters 2021. .
- Attend our 2-hour meeting each week, time TBD.
- Work 4-6 hours outside of the class meeting.
- Register for 2-3 credits of HCDE 496/596.

B. Research Group Roster

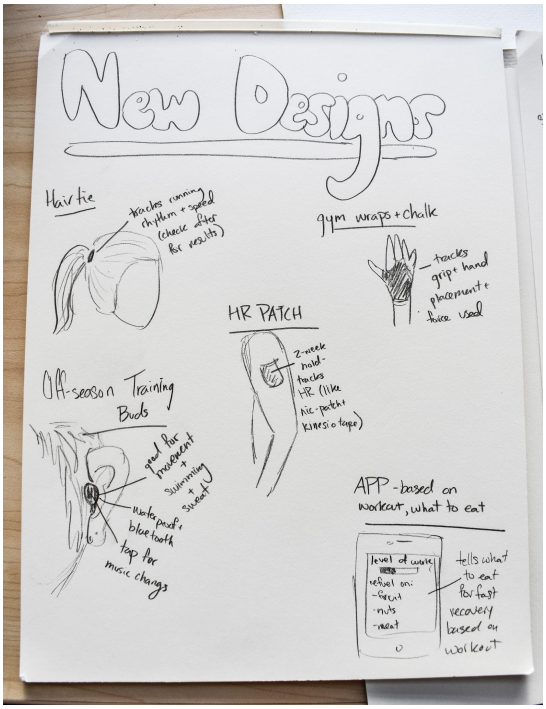
Student-athletes	**Art & Design Students**	**HCDE Students**
Jenna Phillips, Women's Rowing Claire Marion, Women's Rowing Lark Skov, Women's Rowing Brandon, Men's Tennis	Ciana Yi, Design Dustin Mara, Visual Communication Nicki Chan, Industrial Design Chris Hong, Design	John Paul Fallon, HCDE BS Naomi Chau, HCDE BS Drew Nevins, HCDE MS

C. Winter 2021 Research Group Syllabus (Design Phase)

Week	In Session	For Next Week
1 (1/5)	**Introductions** 6:00-6:30 // Introductions 6:30-6:45 // What exactly are we doing here? ● "Syllabus" ● Expectations ● How did we get here? 6:45-7:00 // Speculative Design 7:00-7:30 // Activity ● Small group discussions of Uninvited Guests and Our Friends Electric 7:30-8:00 // For next week ● Logistics ● About video sketches & sketching	Read: Human Hazmat Read: Crafting the Speculation Make: Video Sketches (Does NOT have to be sports/tracking related) 1. Pick an object in your home. Make a video sketch telling us what it can do in a preferred future. 2. Through a second video sketch, **tell a story** that offers a critique of that technology or raises a question about how it is used. Make sure to write down what that critique or question is.

2
(1/12)
	Brainstorming
	
	6:00-6:30 // Reading review
	● Human Hazmat (comics)
	● Crafting the Speculation
	
	6:30-7:00 // Video Sketches review
	● Reflection (5 minutes)
	● Peer review (25 minutes)
	
	7:10-7:50 // Values
	
	7:50-8:00 // Wrap Up
		I suggest giving yourself a time limit for all of these things. Maybe 30 minutes per reading and per video sketch.
		
		Read: Fit4Life
		
		Watch: https://youtu.be/YJg02ivYzSs
		
		Create
		
		1. Value Scenario
		  1. What is your preferable, desired future for the use of tracking technology in college sports?
		  2. Imagine tracking technology is ubiquitous/pervasive/widespread in college sports
		  3. Think about 5, 10, 15, 20 years from now.
		2. Video Sketch
		  1. Identify a value tension and illustrate a scenario in this preferred future through a video sketch
		  2. Use things in your home!

3 (1/19)	**Brainstorming/Ideation** 6:00 — Would You Rather? 6:05 — Where are we? And apologies & acknowledgement of stress, struggles, the world 6:10 — Fit4Life 6:30 — Value Scenarios 7:00 — Value Tensions + Past Data 7:50 — About sketches for next week Note: we will definitely revisit the Hyper Reality video in the future. Was included more for inspiration this week.	20 Sketches (hand drawn or drawn on tablet). More about sketches below. Upload your sketches to next week's Miro board. ● 5 of future/speculative technologies for college sports ● 5 of preferred uses of technology in college sports ● 5 of dangerous/not preferred uses of technology in sports ● 1 of the worst idea technology idea you can come up with ● 1 of the worst use case you can think of ● 1 of the most idyllic idea for technology you can come up with (can be "pie in the sky") ● 1 of the best use case you can think of ● 1 of anything else you like NOTE: ● Technologies should lean towards "tracking" technologies but if you have other ideas please add them! ● Technologies can be a single part or a system of things. Additionally, technologies could be entirely new things that don't exist or things that already exist but you extend/speculate/combine them into something new. ● For the use cases — you could think of a use case around a technology you sketched or speculate on a future use of a current technology. **Sketching** Sketches should be hand drawn and be "sketchy", "rough", or "low-fidelity". Stick figures, "bad" drawing is okay. As with video sketches the goal is to convey your idea. IMO the only type of bad sketching there is is a sketch that doesn't convey anything. Use annotations to describe what is going on in your sketch or different parts of you sketch. See example below from a past DRG.

		
4 (1/26)	**Review & Critique Ideas** 6:00 // Check-in 6:30 // Reflection 6:40 // Review, Critique, Discuss ideas	**Five Storyboards.** For next week we will practice our storytelling around our ideas. Upload to next weeks Miro board. ● Use ideas from sketches! ● *At least two our of your five should be based on /build on someone else's idea*. The goal of this is to look at other people's ideas, get familiar with them and practice **building** on each other's ideas. ● Find templates online, or sketch individual panes and put together on Miro. ● Should be about 6 panels long. ● See resources in this Miro board for help with storyboarding (also on google drive). For now we can keep the focus on communicating the idea and general storytelling and focus less on the cinematic elements of storyboarding like lighting or angle. **Join Slack:** https://join.slack.com/t/uw-p8d7503/shared_invite/zt-li7kl984-67uJEKzeSUpxcRiqHrbXtA **Feedback on review of ideas?**

5 (2/2)	**Review & Critique Ideas** 6:00 - 6:20 // Check in & setting the stage 6:20 - 6:45 // Group review & discussion 6:45 - 7:00 // Share out & review 7:00 - 7:30 // Group review & discussion 2 7:25 - 7:45 // Share out & review 7:45 - 8:00 // Next week	**Iteration!** Iterate on one of your own ideas and one of someone else's ideas. ● Use whatever method you want (video sketches, storyboards, or sketching) but can be different between ideas. Use most appropriate method to convey ideas. ● What are the most important stories to tell? What stories do you want to tell? ● Think about *combining* multiple ideas. ● Think about going back to the *value tensions* we talked about. Start with a technology and highlight a tension between coaches and athletes. Or start with a tension and figure out which technology might highlight this best. S**end** Sam on slack: 1. Favorite / most exciting coach-athlete scenario/tension to you (if you can't decide, just tell me the things you would be most excited to work on). 2. On a scale of 1-5... ○ Comfort level of shooting videos ○ Comfort level of editing videos ○ Comfort level with storytelling ○ Comfort level / knowledge of scripting ○ Comfort level / knowledge of physical prototyping ○ Comfort level / knowledge of after effects ○ How you feel about writing overall ○ Knowledge of or personal experience as an athlete or the coach-athlete relationship 3. Also please send any other skills/ideas you may have that you think would be relevant to contributing to our small working groups.
6 (2/9)	**Review & Organize ideas** Goals: ● Figure out which stories we think are most important to tell (converge on ideas). ● Divide into teams — two teams of 3, one team of 4, everyone excited about what they are working on. 6:00 - 6:10 // Check in (+ slack tips) 6:10 - 6:30 // Review	1. **What story do you think is most important to tell (within your group's direction)?** Prepare for the first team meeting (in session) by preparing a pitch -- use sketches, video storyboard sketches, or any other material we have created so far and tie several ideas together to make a pitch to your team. You may iterate on an idea to make your pitch. Your pitch should be 3-5 minutes. 2. Register for Spring quarter 3. Survey for Spring quarter time?

	6:30 - 7:00 // Convergence 7:00 - 7:30 // Working groups? 7:30 - 7:45 // Organize? Decide? Vote? 7:45 - 8:00 // What comes next!	
7 (2/16)	**First Team Meetings** 6:00 - 6:10 // Check in 6:10 - 6:25 // Reflection 6:45 - 7:30 // Team Meeting + Pitches 7:30 - 8:00 // Team Planning Goals: **Teams decide what direction they will take. What speculative artifact or idea will you explore? What value tension will you explore?** Note: I will try not to be a "wet towel" in team discussions..	1. Sketch, storyboard, or other assignment for your team! You will make a plan as a team for what you will do going forward so this will depend on your team discussions. 2. Register for Spring quarter HCDE 496/596 (2 credits) ● Undergrad SLN: 21462 ● Masters SLN: 21461 ● Code (everyone): 10105 3. Survey for Spring quarter time: https://www.when2meet.com/?11069382-txMvY
8 (2/23)	**Team Meeting 2** 6:00 - 6:15 // Check in & Reflection Response 6:15 - 6:30 // Final Deliverables Info 6:30 - 6:35 // Team Meeting Agenda 6:35 - 8:00 // Team Meeting* * If you feel you are done early, please call Sam into your breakout room first then once we've checked in you're good to go.	TBD (Team dependent)
9 (3/2)	**Team Meeting 3** Teams decide which story they want to tell. At this point groups should have: Storyboards -- sketched Sketches -- of tech Personas -- to help create characters in their story	Teams prepare presentations.
10 (3/9)	**Presentations** Reflect on the quarter progress and what we learned. Review plan for next quarter Settle meeting time for Spring 2021	Enjoy spring break!

D. Spring 2021 Research Group Syllabus (Development Phase)

This quarter was difficult to prescribe due to the variation between the groups and the videos. This is the rough outline that was followed.

Week	**In Session**	**For Next Week**
1 (3/29)	Planning: What will we need to pull this off? Script Props -- including tech prototype or stand-in prop Actors Setting Talk about Scripting/Screenwriting	Teams decide who will work on what. Main efforts here should be on: - Scripting - Props/tech
2 (4/5)	Review Scripts	Iterate on scripts, props
3 (4/12)	Review Scripts	Iterate on scripts, props
4 (4/19)	Shot List Teams work on their shot list for the video.	Finalize shot list.
5 (4/26)	Make plan for shooting video(s) Teams schedule times to shoot the video according to the shot list.	Shoot video
6 (5/3)	Check-in, Use time to shoot video?	Shoot video
7 (5/10)	Check-in, Use time to shoot video?	Start editing rough cut
8 (5/17)	Check-in. How are things coming together? Critique.	Editing Other team members pull together materials.
9 (5/24)	Editing Critique	Editing Other team members pull together materials.
10 (5/31)	Final Videos	Final reflections

E. Video Concept Presentations and Screenshots

The presentation of the video concepts that concluded the design phase can be viewed here: Presentations (Week 10). Additionally, I wanted to include the following select screenshots of the ideation process that include some fun speculative ideas we did not select for the videos.

Figure 19. Examples of the sketches shared during the ideation process that were discussed with the constellation of similar ideas, questions, and comments that were added during the discussion.

III. Organic Reactions to the Videos (Study 2b)

This section contains information about the online dissemination of the videos from Study 2.

Total Views

All three videos have just over 100 views each as of August 2022: Video #1 Informonocle has 113, Video #2 Clippits has 116, and Video #3 EnVisible has 132.

Social Media Posts to Generate Conversation

The research team made several attempts to generate conversation on LinkedIn, Twitter, Reddit, Instagram and Facebook. These posts included questions alongside links to the videos to prompt discussion. Posts on LinkedIn, Twitter, and Facebook were responsible for recruiting some of the participants. And only one post made on LinkedIn generated any reactions of substance.

Reactions of Substance

The only comments of substance were in reaction to a post I made on LinkedIn. I made a general post (see Figure 16) describing the project and asking for thoughts in response to the video. This post was reposted by Scott Clark whose new post (see Figure 16) and follow up comment (see Figure 17) showed that he understood the intentions of the project but did not describe any specific reaction to anything in the videos or describe a preferred future. He did ask a few folks to add their thoughts on the project and one responded (see Figure 18).

This replying comment made by Cameron Stevens is the only real reaction of substance generated organically online.

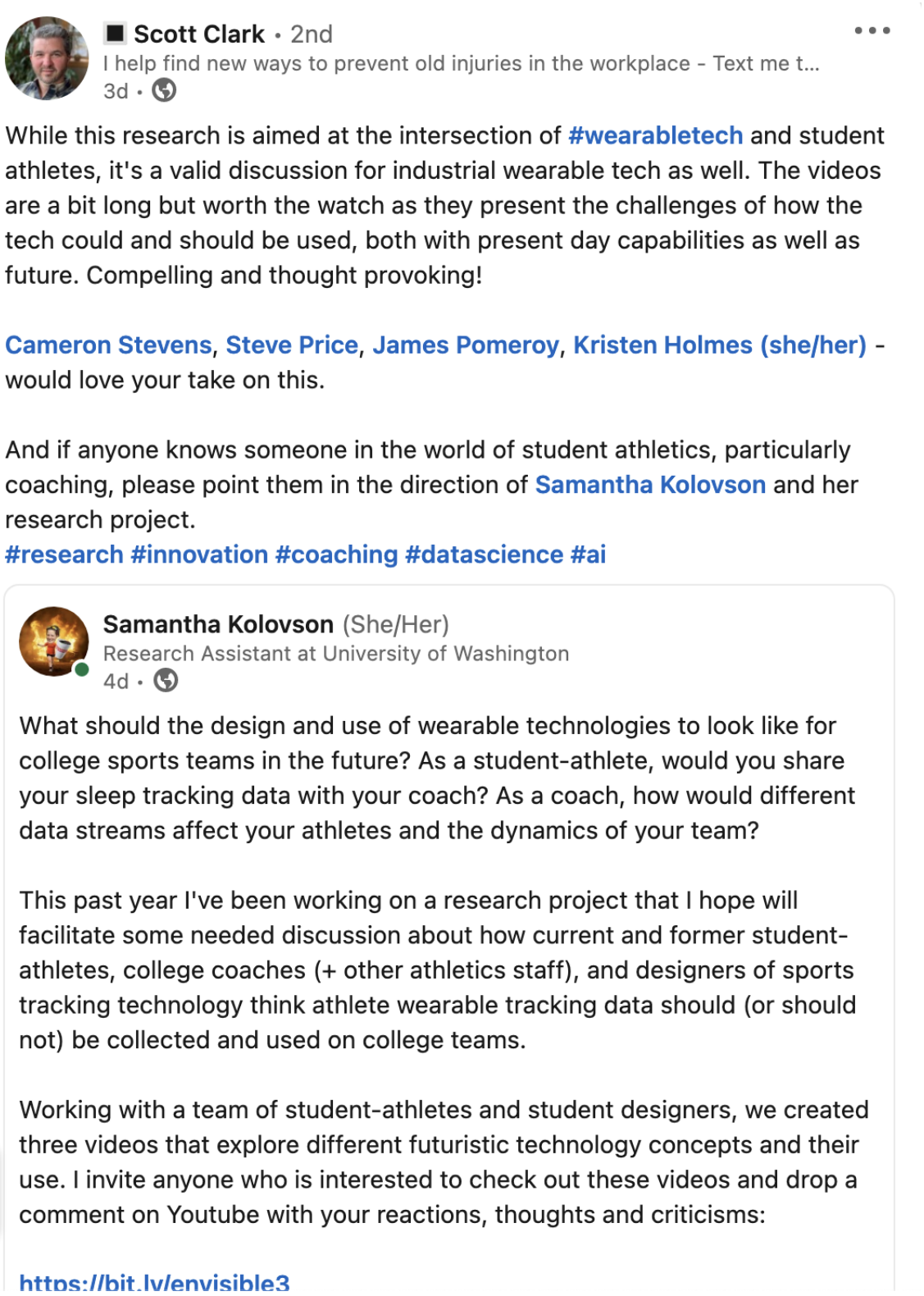


Figure 16. Repost of my post made by Scott Clark. Here you can read the contents of the post I made and what Scott said when he made the repost of it.

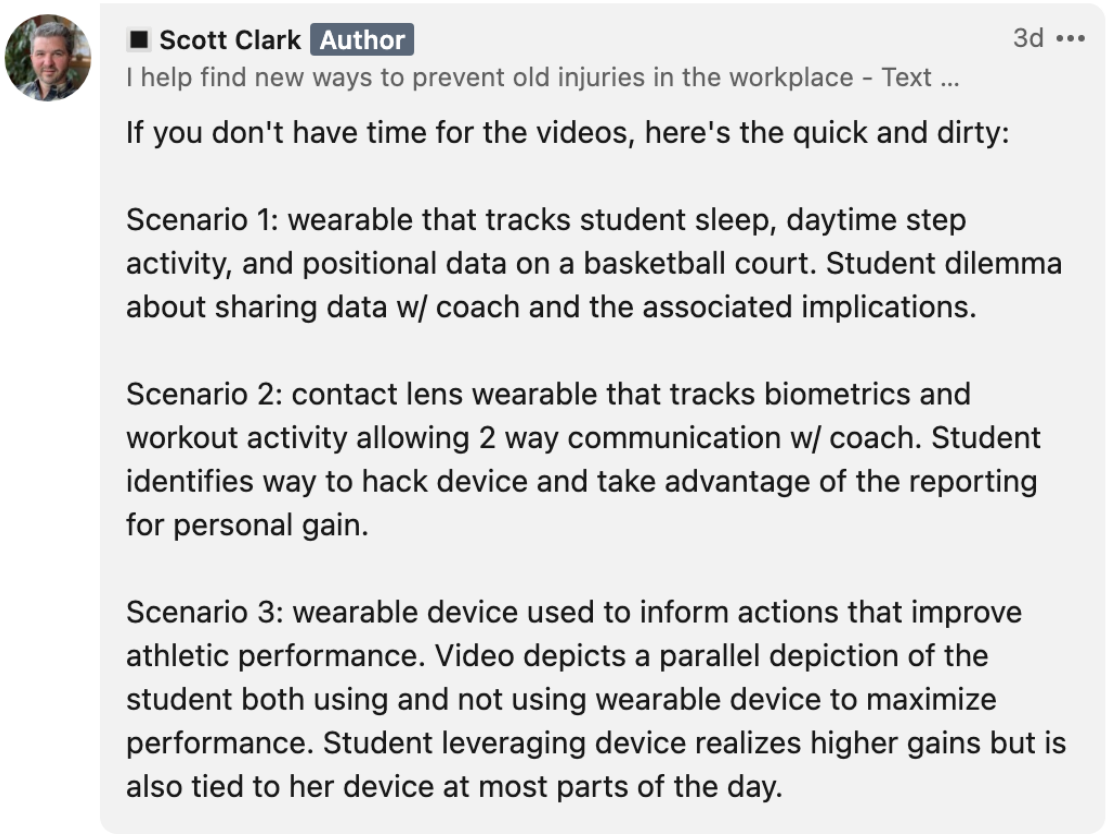


Figure 17. Scott added a comment to his repost describing each of the videos so that others could engage even if they did not have time to watch the videos. This comment does not add anything to the discourse but is remarkable because Scott describes each of the three scenarios in a few short sentences and his descriptions are close to what was intended for each video.

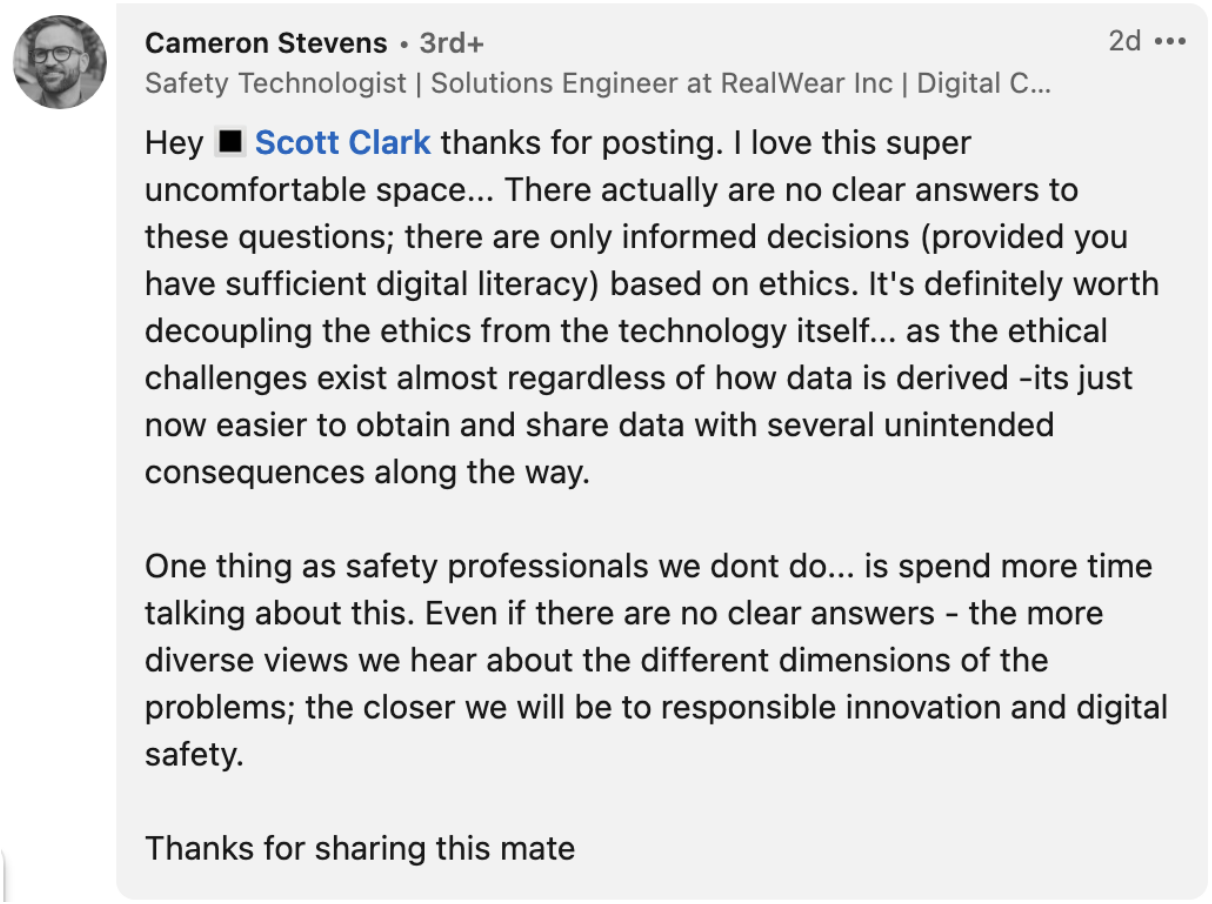


Figure 18. Comment in reply to Scott's repost in Figure 16. This is the only organic comment of substance that added an idea to the discourse.

Why were there not many reactions?

We did not expect the videos to go viral and the videos would have needed at least a small amount of tracking to generate a response. There are also many possible reasons why the videos were not successful in generating many organic reactions. The most likely is that anyone who saw the posts would need to make several clicks to view the videos and the videos themselves were long enough to require additional attention after finally arriving at YouTube to watch them. If we had created shorter clips to share in a TikTok or Instagram Reel to grab viewers attention this may have been more successful in getting more views and generating more organic reactions. It is also possible that the post content was not engaging enough to push viewers to click on the links to the videos and/or that the videos themselves did not draw viewers in enough or produce enough of a reaction for viewers to comment.