An Interdisciplinary Approach to Sports Analytics in a University Setting

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***Abstract*— As of 2019, sports analytics has grown to be a $780 million industry [1]. Many organizations and institutions contribute to the field through research in exercise science, optimization of in-game decision making, sports marketing, business performance, and sports compliance fields. We propose an open, interdisciplinary approach to sports analytics within institutes of higher education to work across many fields and provide opportunities to diverse members within the community, enable research and communication across fields, serve the surrounding community, and ethically use data.**

Keywords—sports analytics, systems analysis, volleyball, lacrosse, design of a center

I. Introduction

Researchers forecast the sports analytics industry to grow into a $5.2 billion industry by 2024 [2]. Professional and collegiate sports teams are interested in using performance tracking technology and analytics tools. Additionally, there are at least 17 universities that offer minors, majors, masters, and certificates focusing specifically on sports analytics [3]. With the continuous growth of data collection and modeling techniques within the data science field, there are unique opportunities in the sports analytics industry for universities to capitalize on.

While the sports analytics industry is growing, few professional and collegiate teams share their findings to retain a competitive edge. There are organizations like the Gatorade Sports Science Institute, MIT Sloan Sports Analytics Conference, and Sports Analytics Club Program that are attempting to build upon existing research and share information, but do so with little success because of the limited community participation or research questions they are attempting to answer [4], [5], [6]. Many organizations narrowly focus on exercise science, optimization of in-game decision making, and other competition or health-focused research. This leaves many opportunities to apply the same analytics research to sports marketing, business performance, sports compliance fields, and other segments of the industry shown in Figure 1. Currently, the field of sports analytics is left in a segmented and incoherent state due to the limited sharing and research in small communities. We propose an open, interdisciplinary approach to creating a sports analytics center within institutes of higher education that provides opportunities to serve society, cultivate vibrant communities, enable research and communication across fields, strengthen various aspects of the institution's foundation, and collect and use data ethically.

Fig. 1. Segments of the Sports Analytics Industry as defined by a report produced by Markets and Markets [1].

II. Review of Research

A. State of Sports Analytics

As the sports analytics industry grows rapidly, professional sports teams have started to incorporate analytics into their operations and strategy. Baseball uses analytics in recruiting and contract development [7]. Football has explored in-game decision optimization and athlete performance [8]. Individual basketball players have worked with analysts to improve performance, while teams have explored analytics to optimize rest time for their players [9]. Figure 2 displays which franchises across all major professional sports have the strongest analytic staff, the most adoption of analytics by coaches and executives, invested the most in biometric data, etc. [10].

More job opportunities are available in professional sports because of their investment in sports analytics. In response, universities are offering more classes, minors, and majors in sports analytics. Syracuse University's Falk College offers majors and minors in Sports Management and Sports Analytics. In addition to these degrees, students can get real-life experience by participating in sports analytics clubs that work with both professional teams and the respective university's teams [11]. The focus for the clubs and majors is less on sports science or research, but more on statistics and mathematics.

ESPN- The Great Analytics Ranking Top 10 (in order from 1 to 10)
Philadelphia 76ers (NBA)
Houston Astros (MLB)
Houston Rockets (NBA)
Tampa Bay Rays (MLB)
Boston Red Sox (MLB)
New York Yankees (MLB)
San Antonio Spurs (NBA)
Dallas Mavericks (NBA)
Oakland Athletics (MLB)
Chicago Blackhawks (NHL)

Fig. 2. Top 10 teams using analytics done by researchers and experts from ESPN [10].

The University of Michigan established the Exercise and Sport Science Initiative (ESSI) to "optimize physical performance and health for people of all ages and abilities." [12] This is a research-based initiative working on the development of sports sensors to collect extensive data used in injury prevention and performance optimization. For larger sports analytics focus, the University of Michigan also has the Michigan Sports Analytics Society. This society has partnerships with both the University's athletic department and professional sports teams. It also hosts an annual Michigan Sports Business Conference [12]. Since 2012, the conference attracts many attendees each year and has had many notable speakers such as Sean McManus, the chairman of CBS Sports [13].

Similar to the University of Michigan, the University of Virginia has a focus on sport sciences. There are multiple professors, as well as labs and institutes, working with the athletic department regarding the health and performance of individuals of different abilities and ages. Currently, the work done by professors is not centralized nor does it have a sole focus on sports analytics. However, many different schools have demonstrated an interest in sports-related projects.

Additionally, sports analytics provides a unique outlet to engage with members of the youth community. Many students at a young age, especially those from a marginalized group, have trouble connecting with the material taught in a STEM field [14]. Sports analytics can provide these students with a case-based learning opportunity to grapple with some STEM topics directly used in higher education and professional fields. Not only would it expose them to STEM concepts, but it is also a way for those students to develop professional skills like communication and team/interpersonal skills, systems thinking, and a learning/adapting mindset [15]. Many students, no matter their background, engage in athletic programs outside of school. Tackling case studies related to the activities they take part in after school creates a unique connection to what they are learning.

B. Issues within the Sports Analytics Field

The sports analytics field faces many issues hindering it from growing even faster than it is now. One issue is a mix of enthusiasm when sharing findings. Some teams, like the Philadelphia Eagles, are willing to talk about their use of sports analytics and share their desire for greater incorporation of analytics into the sport. For example, they shared with ESPN that analytics helped them decide to run the Philly Special in the Super Bowl, which was a defining moment in the game and led to their eventual victory [16]. Other teams see the potential of sports analytics and optimize in-game decision making but try to keep this advantage a secret/competitive advantage. This sometimes leads to cheating, such as in the case of the Houston Astros. During the 2017 World Series, which the Astros won, the Astros were sign-stealing. "Players decoded the catcher's signals from a live video feed, then communicated the signal to the hitter by banging a trash can in the tunnel near the dugout" [17]. Even before this scandal, the Astros were using video modeling and algorithms to pick up pitcher's subtle movements [17]. This scandal shows the dangers of sports analytics and how it can change the game for the worse.

Sharing advancements is also mixed for universities, but different reasons. Researchers at other universities are less likely to see a study and the corresponding results if the study takes place directly with a team in the athletic department. Researchers and the public are more likely to have access to a study sponsored or performed by a lab or outside entity. Better access allows the industry to grow because people can use and build on this published, open research.

Another issue is the security and use of an athlete's biometric data. There is a fear that one day an athlete's data will work against him/her or potentially harm him/her. A recent example of this is the story of Mary Cain and the Oregon Project. Mary Cain is a professional runner who joined the Nike Oregon Project right out of college. During her time with this training group, coaches measured different data points about her body, but the data point believed to affect her most was her weight. Her coaches told her the lighter she was the faster she ran. This led to her taking unnecessary drugs, causing her both physical and mental health problems [18]. The focus was too much on the data rather than the pain it was causing her.

Additionally, some college athletes may not trust the data produced by wearable sensors and what is done with it. At the University of Michigan, a $170 million contract allowed Nike to collect data from student-athletes wearing Nike's sensors. A hidden clause granted Nike "the right to utilize … Activity-Based Info… in any media…" [19]. While analytics can enhance performance, it can also threaten privacy and damage relationships. Requiring student-athletes to wear sensors, such as Nike's, may break the trust between athletes and coaches.

Finally, some people contend data collection and automation can be dangerous when it marginalizes the human expert. To those critics, data analytics is no better than traditional coaching. They argue they do not need advanced technology to improve their players' performance, and because sports situations are unique, they cannot be reduced to numbers [20]. A good coach must know a player's mental state, personal life, and relationship to competitors, all requiring human expertise.

This conflict is embodied in the career of Paraag Marathe, the chief operating officer for the San Francisco 49ers. Marathe, a Stanford MBA and former consultant with extensive analytics experience, has been disparaged as not a pure "football guy", meaning others believe he cannot fully understand the nuance of human interaction between a coach and his/her athlete [20].

III. Center Objectives

A systems analysis produced design goals for an interdisciplinary center for sports analytics that capitalizes on the opportunities within the field while mitigating the current issues. The team defined scenarios of what this approach currently does and should look like, as well as interviewed stakeholders to identify values and goals that should be embedded in the center. To generate the requirements needed to create an interdisciplinary design, the team researched policies for creating academic opportunities, engaging with athletics, and collecting data. The University of Virginia is home to many projects within sports analytics that already cross traditional boundaries. Members of the School of Engineering and Applied Sciences have worked with the UVa football staff and other athletic department personnel to develop analytical models to improve recruiting methods and in-game decision making [21], [22], [23], [24]. Due to the unique work occurring at the University of Virginia, the objectives listed in Figure 3 were first designed and influenced by the University of Virginia's president, Jim Ryan, and his 2030 plan. However, the objectives were crafted in such a way that any university can adopt the objectives and metrics to create an interdisciplinary sports analytics center within their respective institution.

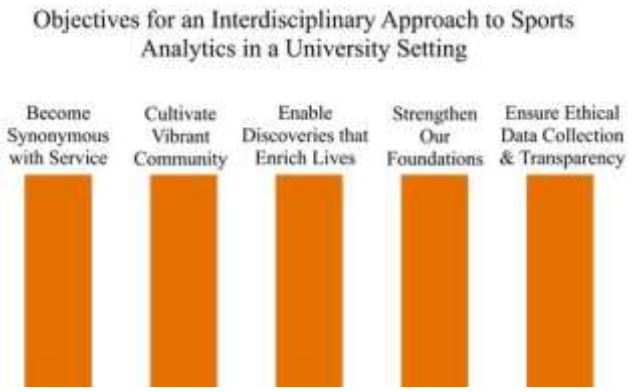

Fig. 3. The five high-level objectives essential to creating an interdisciplinary approach to sports analytics in a university setting.

A. Make an Institution Synonymous with Service

The working definition of service used is serving those within the university and the community surrounding the university. Some sub-objectives of this goal are to increase student exposure to the field of analytics, provide opportunities to pursue analytic post-graduation careers, and improve community health education. The determining factors of the success of this center include the number of students pursuing jobs or internships with an analytics component, the percentage of university athletes monitoring their health, and the percent change in serious injury as a result of improving training methods through analytics.

B. Cultivate a Vibrant Community

Cultivating a vibrant community in higher education and in particular, within a hub for interdisciplinary sports analytics, means strengthening ties with the community surrounding the institution and establishing long-term alumni and business relationships. To measure if the interdisciplinary approach succeeded in doing this, those involved can see the number of local students positively impacted, the number of engagements with community organizations, the number of alumni actively engaged, and the number of corporate partnerships set up within the respective center.

C. Enable Discoveries that Enrich Lives

To achieve promoting and supporting impactful research within sports analytics, there exist sub-objectives to improve the performance of the athletic department, promote student involvement in sports analytics research, and become an international leader in sports analytics. To measure the sub-objectives and determine the success of enabling impactful research, those involved can look at the number of teams using analytics as well as their Capital One and Learfield Cup rankings, the annual percent change in total revenue for the center, the number of academic opportunities offered, and the number of international students and faculty participating in the center.

D. Strengthen Foundations

It is important to support the people that participate in, and are affected by, the work done within the center. Measures such as providing university staff and teams with equipment to gather data, supporting coaching staff in the athletic department, attracting top students, faculty, and researchers, and improving financials across the university can help strengthen the institution's foundation. To measure the success of achieving these objectives, one can look at the number of devices and analytical tools used without failure, the number of people and departments engaged, the diversity index of those involved in the center, as well as the profitability, sum of donations, sponsorships, etc.

E. Ensure Ethical Data Collection and Transparency

To be a leader in any analytical field, it is necessary to protect the data collected. To ensure the protection of student-athletes' and teams' data, it is important to keep data secured in an appropriate environment. It is also important to keep those whose data is collected informed of how their data is used. To successfully do this, it is necessary to build and maintain a database in a secure, compliant environment, make the database centralized and accessible by teams and students, and continuously check with Institutional Review Boards (IRB) for Health Sciences Research and Social and Behavioral Science Research to ensure data is treated properly.

IV. DESIGN OF CENTER

Many institutions of higher education have the opportunity to adopt the objectives defined for an interdisciplinary approach to sports analytics. The more specific details related to the creation of a sports analytics center fall within four key dimensions: Physical, Educational and Institutional, Outreach, and Research. Many stakeholders at the University of Virginia have worked toward designing such a center, and that design is an illustrative example in the sections detailed below.

A. Physical Dimension

For its feasibility, the center requires some physical space designed specifically for technology use. That space should include potential equipment like laptops, computer terminals, wearable sensors, whiteboards, and screens. Affiliated professors, researchers, and students will need offices and collaborative meeting space. Initially, an existing space on campus could house the center; however, as the center grows, it will likely require more space two or three years down the road to achieve all of its potential goals.

B. Educational and Institutional Dimension

For the first few years, the center will be a collaborative research center between all schools. Schools wanting to join the center can offer classes on sports analytics. Students of the center-affiliated schools would take these classes as part of sports analytics tracks or concentrations. As more students participate in the center and more classes are available, these classes will accumulate to form minors. While individual schools would house a potential minor, all students should have access to the minor. Eventually, the center could house the minor, creating a more collaborative academic opportunity.

C. Outreach Dimension

Beyond engaging members of the university, to best grow the sports analytics industry the center should include communities outside of professional and collegiate sports. Potential options to achieve this goal are to design summer camps for youth organizations, offer continuing education certificates, form partnerships with entrepreneurial groups, and host a sports analytics conference.

D. Research Dimension

Another major component of the center is research. The center must have collaborative research between students, professors, schools, and the athletic department. This will provide real-life experience for students and allow professors to explore topics in athletics. The research will be published in various local, national, and international publications when appropriate. Outlined below are examples that illustrate how valuable multi-field research and collaboration can be to an institution and its community.

V. EXAMPLES OF INTERDISCIPLINARY SPORTS ANALYTICS

A. Women's Volleyball Research

The women's volleyball coaching staff, director of women's volleyball operations, and engineering team conducted a sports analytics project to determine which statistics were most indicative of winning UVa volleyball matches. In the modeling process, cleaning three years of team data took place, and an exploratory analysis of various correlation matrices, statistic tests, and regression models determined which statistics make the biggest difference in games won or lost. Seen in Figure 4, one interesting result showed the average percentage for kills is 40.5% in games won, but the average percentage of successful kills drops to 33.4% in games lost. Further elaboration of these results can occur with more data collection in games and practices, more student involvement, etc.

```
summarize kills gp pp Blocks Digs if wl==1
```

Variable	Obs	Mean	Std. Dev.
kills	29	.4051724	.0493255
gp	29	.7131034	.0813328
pp	29	.3941379	.1030089
Blocks	29	2.893103	.9775264
Digs	29	14.94759	2.374423

```
summarize kills gp pp Blocks Digs if wl==0
```

Variable	Obs	Mean	Std. Dev.
kills	53	.3339623	.0418026
gp	53	.6967925	.0729007
pp	53	.3703774	.0927354
Blocks	53	1.849623	.7154825
Digs	53	13.21075	2.678232

Fig. 4. The summary statistics of kills, good passes, perfect passes, blocks, and digs, which are significant when predicting wins. The top chart represents games won while the bottom chart represents games lost.

B. Men's Lacrosse Research

To further demonstrate the advantages of sports analytics, the men's lacrosse coaching staff and engineering team conducted a project to determine ways they could use analytics to monitor athlete training load and better understand how the team performs against the shot clock. First, to assess an athlete's internal and external training load, the team researched how to optimize the use of wearable devices in conjunction with advice and tests run by the Exercise Science lab at UVa. An important take-away from this research was that none of the wrist-worn devices achieved the same accuracy of a chest-strap-based monitor, but both can be valuable for measuring different data points [25]. A wrist-worn device, like a WHOOP band, is good for monitoring resting heart rate and sleep patterns. A chest-strap-based monitor, like a Catapult device, is more effective at monitoring exercises with numerous movements [25]. Second, to analyze shot clock performance and determine which plays were the most successful for UVa, the modeling process of the team's play-by-play data largely consisted of cleaning and adding additional explanatory variables. Figure 5 shows the UVa lacrosse team is more likely to turn the ball over in the first 20 seconds of the shot clock, but the opponents they face are more likely to turn the ball over in the first half or 40 seconds of the shot clock. This research and work can expand to the UVa women's lacrosse program as well as other programs within the community, such as club and high school teams.

		Early	Middle Early	Middle Late	Late
Opponent Turnover	Actual Count	246	82	47	26
	Expected Count	283.36	60.33	38.55	18.96
	Residual	-37.36	21.67	8.65	7.04
	Adjusted Residual	-4.233	3.127	1.516	1.712
Virginia Turnover	Actual Count	209	26	50	26
	Expected Count	252.27	16.88	34.15	16.88
	Residual	-43.27	9.12	15.85	9.12
	Adjusted Residual	-5.176	2.341	2.936	2.341

Fig. 5. The results from a Chi-Square test shows the UVa lacrosse team's likelihood of turnovers during different periods of the shot clock.

VI. CONCLUSION

We propose an open, interdisciplinary sports analytics center within institutes of higher education with the following main objectives: become synonymous with service, cultivate vibrant communities, enable discoveries that enrich lives, strengthen foundations, and ensure ethical data collection and transparency. Though this paper focuses on a case study implementing this type of center specifically at UVa, different universities can implement a comparable pan-university center through similar steps. First, the university needs to identify and foster interest in sports analytics. Second, it needs to understand and meet the objectives stated above. Finally, the university should ensure the consideration of each Physical, Educational and Institutional, Outreach, and Research dimension. Depending on the monetary needs and desires of the respective university, not all these dimensions need to be met as extensively as in the UVa case study. However, these dimensions do encompass the necessary components of a successful center.

It is imperative to have this center be interdisciplinary because sports analytics does not just rely on one field of study. Within sports analytics, there is an opportunity to study and research biometric data, business data, game statistics, sports policies, and more. If the focus of the center is in one school on one major, it loses the opportunity to research and discover insights from other related topics. A center with involvement from many stakeholders within a university community creates an opportunity for more focused and in-depth projects. Combining many different fields of study and points of view will generate the most impactful projects and research that will influence the sports analytics industry for years to come.

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