The SPORT-C Intervention: An Integration of Sports, Case-Based Pedagogy and Systems Thinking Learning

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Abstract

The STEM field is unrepresentative of the population it serves. Due to a lack of cultural relevance in STEM courses, there is a dissociation between the lived experience of students from underrepresented racial groups (URG) and STEM course material. A review of existing literature presents an opportunity in sports cases infused with systems thinking learning to motivate students who have traditionally struggled to become interested in STEM topics. The SPORT-C intervention is a framework that combines sports, systems learning, and a case-based pedagogy into an activity that can be used in any STEM course. A pilot study was conducted to determine the viability of the SPORT-C intervention in a classroom setting and determine if it was worth further investigating and if any impact differed by racial identity. The findings from this study implicate that the SPORT-C intervention may have an impact on the motivation levels of students to participate in STEM courses.

Introduction

The STEM workforce needs racial diversity. Those who identify as Black or African American, Hispanic or Latino, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander are underrepresented in the workforce, collectively making up 15.1% of the STEM workforce despite making up 31.9% of the United States (U.S.) population (Burke & Okrent, 2021; US Census Bureau, 2020). These races and ethnicities are further referred to as underrepresented racial groups (URGs). In contrast, while Whites make up 66.2% of the STEM workforce, they only make up 60.1% of the U.S. population; Asians make up 16.3% of the workforce but just 5.8% of the U.S. population (Burke & Okrent, 2021; US Census Bureau, 2020). These races and ethnicities are further referred to as overrepresented racial groups (ORGs).

Lack of representation in the STEM workforce can lead to innovations that are ineffective at addressing problems that adhere to the needs of all people. A lack of workplace diversity often hinders productivity, creativity, economic growth and society's ability to address health needs (Boekeloo et al., 2015; Burke & Okrent, 2021; Cian et al., 2022; Drazan, 2020a; Flabbi et al., 2019; Quiroz-Rojas & Teruel, 2021). STEM education serves as a pipeline for diversifying the STEM workforce (Olson & Riordan, 2012; Palmer et al., 2017; Scott & Martin, 2014). Previous research has established the importance of early interest in STEM as a critical factor in remaining persistent in the field (Maltese et al., 2014; Tai et al., 2006; van Tuijl & van der Molen, 2016). The present pipeline fails to capture youth for whom STEM remains remote and outside their current experience (Drazan, 2020b).

This study proposes and tests a novel approach to addressing lack of representation in STEM education through the innovative integration of sports and case-based systems thinking learning.

Literature Review

Background

Diversity in the STEM Field

In 2019, workers in the STEM field[1] made up 10.4% of the total U.S. workforce (Burke & Okrent, 2021). Of that population, only 15.1% of workers identify as URGs, despite the fact that URGs account for 31.9 % of the population in the United States (Burke & Okrent, 2021; US Census Bureau, 2020). Although making up over 30% of the U.S. population, URGs account for less than 20% of the entire STEM workforce population. In contrast, Whites make up a majority of the U.S. population at 60.1% yet constitute 66.2% of the STEM workforce population (Burke & Okrent, 2021; US Census Bureau, 2020). Asians, despite being a minority in the United States with only 5.8% of the population, make up 16.3% of the STEM workforce population (Burke & Okrent, 2021; US Census Bureau, 2020). In total, White and Asians make up 65.9% of the U.S. population, yet 82.5% of the STEM workforce, an overrepresentation of their demographic. Lack of representation in the STEM workforce can lead to innovations that are ineffective at addressing problems that adhere to the needs of all people. Racial variety in the STEM workforce can lead to technological advancements that are inclusive in their design, robust in the problems they are addressing as well as the demographics they serve (Boekeloo et al., 2015; Cian et al., 2022; Wulf, 1998).

[1] STEM workforce is defined as those on those employed in a science & engineer (S&E), S&E-related or middle skill occupation with a bachelor's degree or higher. The five major categories of S&E are (1) Computer and mathematics scientists; (2) biological, agricultural, and environmental life scientists; (3) physical scientists; (4) social scientists; and (5) engineers. Workers in S&E-related occupations use science and technological expertise, such as doctors, engineering managers, computer programmers, and biological technologists. S&E and S&E related occupations make up 60% of the STEM workforce; the other 40% are middle-skill occupations. Middle-skill occupations require significant STEM expertise but do not require a bachelor's degree. Middle-skill occupations include those in construction and extraction; installation, maintenance, and repair; production and others. (Burke & Okrent, 2021)

STEM Education and the STEM Field

Studies have shown how STEM career aspirations are linked to the pursuit of STEM education (Atherton et al., 2009; Bøe et al., 2011; Maltese & Tai, 2011; Sheldrake et al., 2019; Tai et al., 2006). Previous research has shown that early interest in STEM subjects is important in remaining committed to the field. (Maltese et al., 2014; Tai et al., 2006; van Tuijl & van der Molen, 2016). According to studies, by the age of 14, children's attitudes and interest in the pursuit and study of science have waned from their peak at age 10 and have also solidified (Archer et al., 2010; DeWitt et al., 2014). Studies have also reported a negative trend of interest and aspirations in science during the lower-secondary school years (Hong & Lin, 2011; Kang et al., 2021; Potvin & Hasni, 2014b; Sorge, 2007). These studies further showcase the importance of fostering interest in the field early through STEM education. The majority of students who focus on STEM do so in high school, and their decision is based on a growing interest in math and science (Maltese & Tai, 2011). Science study in the final years of school is crucial to the flow of scientifically prepared individuals necessary in our modern society since teens' subject selection decisions influence their possible career paths (Palmer, 2020; Palmer et al., 2017). STEM education during a student's formative years impacts their desire to pursue a STEM degree later in life. Young adolescents who expected to pursue a career in science were more likely to complete a science degree in college, highlighting the importance of early encouragement (Tai et al., 2006; van Tuijl & van der Molen, 2016). Efforts to increase the number of URG students by influencing their career aspirations during adolescence could help shape the sector's future (Kohen & Nitzan, 2022; Roberts & Wassersug, 2009; Shwartz et al., 2021). Given the country's rapidly shifting ethnic demographics, increased access and opportunities for URG students to seek, persist in, and succeed in STEM education will be critical in establishing a diverse STEM workforce in the United States (Palmer et al., 2017; Scott & Martin, 2014).

Educational Context

According to the existing literature, one effective way to increase students' STEM career interest is to communicate the personal and social values of STEM and the connections between STEM and the real world. (Harackiewicz & Hulleman, 2010; Sheldrake et al., 2019; So et al., 2020; van Tuijl & van der Molen, 2016). Diekman et al. (2011) found that introducing to students how STEM careers are relevant to their everyday lives can positively motivate them to seek careers in STEM. Aspirations in STEM are influenced by, but not limited to, extrinsic motivations such as utility or value of STEM[2] and relevancy to everyday life[3] as well as intrinsic motivations such as interest in STEM[4], self-efficacy/self-perception/self-concept in STEM courses[5], attitudes towards STEM[6], and sense of belonging/ identity in STEM[7]; no single factor influences aspirations in STEM (how these terms are utilized in the context of the this paper are discussed in later sections). Given that extrinsic and intrinsic motivations are key predictors of success in STEM courses, educators should identify the underlying factors that prevent students from making a meaningful connection to the educational context.

A disconnect between students and their learning context can also lead to a drop in motivation and academic performance, subsequently affecting aspirations within that field of context (Sheldrake et al., 2017). Culturally relevant pedagogy strongly suggests that a student's

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[2] (Bøe, 2012; Mujtaba et al., 2018; Wang et al., 2020)
[3] (Diekman et al., 2011; Hill et al., 2018; Sheldrake et al., 2017, 2019; So et al., 2020; van Tuijl & van der Molen, 2016)
[4] (Friend, 2015; Hill et al., 2018; Kang & Keinonen, 2017; Mujtaba et al., 2018; Palmer, 2020; Potvin & Hasni, 2014a; Sheldrake et al., 2019; Wang et al., 2020)
[5] (Aschbacher & Ing, 2017; Avargil et al., 2020; DeWitt et al., 2011, 2013; Kang & Keinonen, 2017; Luo et al., 2021; Mujtaba et al., 2018; Potvin & Hasni, 2014a; Sheldrake, 2020; Shwartz et al., 2021; Wang et al., 2020)
[6] (Atherton et al., 2009; DeWitt et al., 2011, 2013; Ormerod & Duckworth, 1975; Potvin & Hasni, 2014a)
[7] (Bøe, 2012; Bøe et al., 2011; Cian et al., 2022; Cleaves, 2005; Hannover & Kessels, 2004; Hazari et al., 2010; Lyons & Quinn, 2010);

connection to the material taught in their courses is essential for academic success (Ladson-Billings, 1995, 2014; Ladson-Billings, 2009). Other prevailing theories such as cultural mismatch (Stephens et al., 2012), identity-based motivation (Oyserman & Destin, 2010), and goal congruity (Diekman et al., 2010) suggest that alignment between a student's background, identity, values, or goals and the educational context serve as successful motivational resources. Developing students' attitudes, and hence their aspirations, by highlighting science's applications and relevance to everyday life may be beneficial. To ensure that STEM classroom environments are suitable for all students' learning experiences, especially those who are URGs, an instructor should be aware of their students' various identities and how each influences their learning experience.

Sports

In 2019, data indicated that over half of high school students participate in school sports, 73% of students ages 6 – 12 and 69.1% ages 13 - 17 (Aspen Institute, 2020a, 2020b; Wretman, 2017). With more than one out of every two students participating in sports activity, it is safe to say most students have interests in this domain. 34.8 % of Black and 34.1 % of Hispanic children aged 6 to 12 played a sport, while 42.4 % of Black and 40.3 % of Hispanic children aged 13 to 17 played a sport[8] (Aspen Institute, 2020a, 2020b). These figures represent the lowest estimate of the number of students interested in sports. Students who are interested in sports but cannot participate due to a variety of reasons such as a lack of availability at school, the fact that some sports have a participation limit due to limited roster space, or the possibility that the student has a disability that prevents them from participating are not included. With 7.1 % of Black and 7.7 % Hispanic workers in the STEM workforce, there is an opportunity to increase participation by these URGs by using sports as a bridge (Burke & Okrent, 2021).

[8] Native American data was not reported, while Asian and Pacific Islander data were reported together.

Sports has been a demonstrated unique approach to engaging students in STEM education as recent studies have investigated the effects of linking sports concepts with STEM learning (Ali et al., 2021; Donaldson & Hammrich, 2016; Marshall et al., 2021). Ali et al.'s (2021) study reported the students appeared completely enthralled by the prospect of investigating the link between sports and engineering, resulting in a strong desire to understand the underlying scientific concepts in sports and thus addressing STEM learning. In addition, the study resulted in growth in their self-efficacy and a positive attitude towards STEM as an educational field and career path. Donaldson and Hammrich (2016) discovered that sports themes not only increase STEM participation and learning STEM concepts but that they also "create an atmosphere that embraces the psycho-social-creative-emotional connection to learning" (Donaldson & Hammrich, 2016). The connection to learning adds depth and relevance to the student learning experience, which is essential for the learning experience of URGs. Marshall et al. (2021) investigated how a basketball camp was used to link participants' basketball self-efficacy to STEM+M topics they feel less adept at. The study results supported the hypothesis that participating in the program would result in initial engagement and a renewed commitment to STEM and would increase STEM identity among the URG cohort. The study also concluded that early intervention in STEM education through informal teaching settings that connect with young students' existing interests effectively generates value and interest in STEM.

Sports incorporated into STEM activities appear to influence students' extrinsic and intrinsic motivation to participate in STEM courses and pursue STEM careers. However, these studies are all conducted in the setting of an out-of-school program. There is no evidence of a study conducted investigating the effect of the integration of sports and STEM learning while in the classroom setting and their effect on differing racial demographics.

Case Based Pedagogy

A case is a description of an actual situation, commonly involving a decision, a challenge, an opportunity, a problem, or an issue faced by a person or persons in an organization, requiring the reader to step figuratively into the position of a particular decision-maker (Herreid, 2007). Cases are a means of linking work with things that matter and have career potential (Wolter et al., 2013; Yadav et al., 2010, 2014). Case-based education can make the curriculum more relevant and motivational for students by challenging them to apply what they've learned to real-life situations. Instructors can use case-based teaching and learning methodologies to facilitate student learning through activities that meet educational objectives and intended student learning outcomes. Students can be successfully exposed to practical problem solving through case-based studies, which push them to examine data, draw conclusions, and design solutions. With active learning at its center, a case-based pedagogy is more effective than a standard classroom setting to engage pupils and create a long-lasting understating of learning material (Leonard et al., 2001; Prince, 2004; Yadav et al., 2010, 2016). Active learning is where students are engaged in the learning process, resulting in a more productive learning experience and material application. Students are inclined to question, debate, and discuss issues and methods as they grapple with realistic problems (Freeman et al., 2014).

Multiples studies have demonstrated the effectiveness of a case-based instructional pedagogy. Case studies have been found to increase students' critical thinking and problem-solving skills (Akili, 2007, 2008, 2011, 2012a, 2012b), self-efficacy in subject material (Holley, 2017; Wolter et al., 2013), subject comprehension (Munakata-Marr et al., 2009), and positive attitudes towards coursework (Ballard & Mooring, 2021). However, few studies have demonstrated the effect of case studies on the learning experience of URGs. For example, Smith et al. (2020)

demonstrate how multidisciplinary cases may be a powerful tool for delving into complex issues and engaging URG students. The research used a set of interdisciplinary cases that addressed meaningful topics in Native American culture. The culturally relevant approach gave Native American pupils a sense of belonging in the classroom, encouraging them to become more involved in their studies. Efforts such as Smith et al. demonstrate how a customized learning experience can positively impact URG students' involvement in their coursework.

Findings from studies centered around the effects of a case-based pedagogy suggest that improving kids' enjoyment, interest, and perceptions of their STEM skill, as well as their judgments of its worth in a future STEM career, may lead to an increase in the number of students studying STEM in school.

Systems Thinking Learning

Systems thinking is comprehending complex interconnected inputs and outputs that work toward a common goal while analyzing problems (Lavi & Dori, 2019; York et al., 2019). Systems thinking utilizes a holistic approach, which encompasses tackling the problem as a whole versus individual parts (Arnold & Wade, 2015; Camelia & Ferris, 2016; Hossain et al., 2020). The problem solver must address all system components, identifying all relationships between its inputs and outputs. Russell Ackoff (1994) provides a great example of the effectiveness of a systems approach. According to Ackoff's 1994 presentation, getting car parts from the company that makes the best part in the industry (for example, getting a transmission from Rolls Royce and an engine from Ford if they were the best manufacturer of these individual parts) would not result in the best vehicle. Because the parts wouldn't fit together, you wouldn't have a vehicle at all. The idea is that a systems approach considers the parts' interrelationships, whereas a reductionist approach only considers the best of each component while ignoring how they interact.

Problem-solving is a fundamental aspect of most career paths and having a high aptitude in this skillset will enable those possessing it to stand out amongst their peers. Systems thinking has become the most valuable skillset for growing organizations with increasing complexity. (Adam, 2004; Arnold & Wade, 2015; Constable et al., 2019; Jaradat et al., 2020). As the industry grows and becomes more advanced in its operations and the technology used to meet business needs, the problems become more complex. With more complex problems, there is a need for problem solvers capable of handling the intricacies of these situations. There is a call for system thinkers in the industry to assist these growing system structures and meet the demands of business goals.

Systems thinking should be incorporated into the classroom to expose future workers to how to address global, socio-scientific issues. Systems thinking has received considerable attention in recent years, with how to teach systems thinking, including how to teach it to K-12 students (Clark et al., 2017; Lavi & Dori, 2019). Educators have already seen the value of incorporating systems thinking into their classrooms and how it prepares students to make informed, ethical decisions about relevant issues (Constable et al., 2019; Delaney et al., 2021; Jackson & A. Hurst, 2021; York & Orgill, 2020). Researchers suggest that children should be introduced to systems thinking at the earliest age possible. Students exposed to systems thinking activities could identify system elements and their interactions in greater numbers and with greater accuracy, according to several studies conducted on participants as young as pre-school (Ben-Zvi-Assaraf & Orion, 2010). Educators who have used systems thinking in their classroom have reported that students are active participants in their learning, learn content more deeply and conceptually, ask better questions, and make more connections between concepts both within and between disciplines (York et al., 2019).

The SPORT-C Intervention

All previously discussed components can positively impact the academic experience of URG youth in STEM education. URG youth tend to lack a motivation to pursue STEM careers and courses as the fields lack relevance to their everyday lives (Hill et al., 2018; Sheldrake et al., 2017; So et al., 2020). Educational context alignment within sports has a proven positive effect on students' self-efficacy, attitude, identity, and interests in STEM, both career and education. Sports serve as a culturally relevant topic that brings value and increases motivation in the academic setting (Ali et al., 2021; Marshall et al., 2021). Case-based pedagogies will showcase to students how their developed skillsets are applicable outside the classroom, fostering a sense of value that increases motivation, academic performance, and engagement (Harackiewicz & Hulleman, 2010; van Tuijl & van der Molen, 2016). Integrating systems thinking into the curriculum will help to build on pre-K-12 content while also connecting to a growing STEM field.

The SPORT-C intervention is a framework in which sports, a case-based pedagogy, and systems learning and are blended into an activity applicable in all STEM courses (see Figure 1).

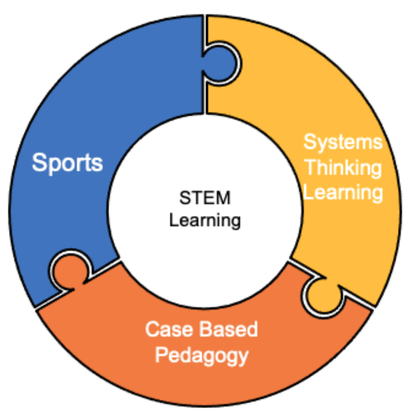

Figure 1 SPORT-C intervention diagram. Displays how each component works together to foster STEM learning

With the SPORT-C intervention, sports are seamlessly incorporated into the classroom curriculum in the form of a sports case. Students will be given a real-world scenario centered around sports that will incorporate the learning objectives for whichever unit they are in their curriculum. The students will need to utilize their current unit's learnings to progress through the activity. In the form of a sports case, the students will simultaneously use the systems thinking problem-solving method to complete the activity. The approach is unique because it combines a systems-based approach with culturally relevant methodologies to encourage students to enroll in STEM courses and pursue careers in the field.

Figure 2 demonstrates an approach to integrating systems thinking within each sports case. Students will begin by first *breaking down the problem*. Students will identify the main objectives of the problem, define metrics necessary to measure success, identify stakeholders and their values to be considered, and state the assumptions to be made moving forward. This step allows for students to gain a holistic understating of the problem at hand and all the components it encompasses. If data is not given, students will be required to *retrieve supplemental data.* In settings outside of classrooms, data is not always made readily available for analysis and sometimes, a bit of research is necessary to address the problem. Next, students will have to *walkthrough and clean their dataset*. Again, data is not always readily available for straightforward analysis and might require a bit of recoding of variables and preliminary work before being deemed usable. This step allows students to become familiar with data set and develop new variables if necessary. After gaining familiarity with data, students will have an opportunity to *develop hypotheses* that they will later confirm or reject after analyses. *The analysis* will require students to use skills gained from the unit's learning objectives to complete. This will serve as the application portion of the activity. Students will be able to tie the relevancy of their lesson to a real-world scenario as they put into practice their classroom learnings. Students then use the results of their analysis to *connect to a decision* answering the initial question asked in the scenario. Tradeoffs, defined as the gains and losses of a decision, will need to be considered for each possible solution and alternative. Lastly, students will be required to *make a recommendation*. This is where students summarize their findings and provide a decision backed up by their analysis performed.

Each developed sports case would follow a process comprised of most, if not all, of these components and each case could go into different depths based on the level of the students and the prerequisite material they had covered. The problem-solving process will provide students a framework for addressing problems they face, not limited to the confines of classroom activity. It is also imperative to note that this process is not a step-by-step process but takes an <u>iterative</u> approach, hence the arrows traveling back and forth between each step. Discoveries made throughout the process may require the student to revisit a previous step and adjust accordingly. This ensures that decisions encompass all components of a problem, even as they are discovered throughout the process. The goal of successfully integrating all components is to pique the interest of K-12 students in STEM, especially those who identify as URGs.

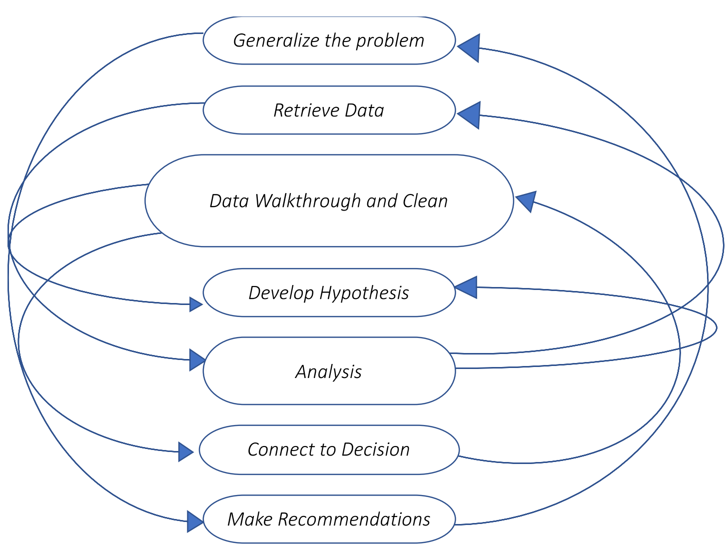

Figure 2 Systems thinking learning

Purpose of Study

The proposed study is to fill in gaps within current research. Sports studies have not focused on the effects of sports-related curricula on students' motivation within the classroom. Research on sports and STEM has been limited to programs' implementation and not classroom learning. Regular classroom lectures do not tend to put students in real-world scenarios. To test the effectiveness of the SPORT-C intervention, a pilot study was conducted to determine its viability in a classroom environment and to see if it was worth exploring further. The research questions that guided this study are:

RQ1: How does the SPORT-C intervention impact a student’s motivation to participate in their STEM course?

RQ2: Does the impact of the SPORT-C intervention vary by racial identity?

The study aimed to understand the impacts of the SPORT-C intervention on the motivation levels of high school students who participate in STEM courses. The motivation was measured by analyzing a participant’s self-reported academic engagement, self-efficacy, expectancy, value, and cost of STEM-related courses before and after students were exposed to the SPORT-C intervention (Lazowski & Hulleman, 2016). Below is how each measured factor is defined in the context of this study.

Academic engagement: Degree of attention, curiosity, interest, optimism, and passion that an individual shows when they are learning or being taught (Great Schools Partnership, 2013)

Self-efficacy: Individuals confidence in their ability to successfully complete tasks (Luo et al., 2020)

Expectancy: The extent to which a student thinks he or she can be successful in a task (Kosovich et al., 2015)

Value: The extent to which a student thinks a task is worth completing (Kosovich et al., 2015)

Cost: Negative aspects of participating in an activity, such as judgments about the amount of effort and time required to be effective or the loss of other valuable activities (Kosovich et al., 2015)

In addition, study participants would take part in a focus group to gain a qualitative understanding of their learning experience while undergoing the SPORT-C intervention. A brief interview with the classroom instructor (CI) was conducted to obtain a different perspective on the impact of the SPORT-C intervention on student motivation levels. A logic model of the study is provided in Figure 3.

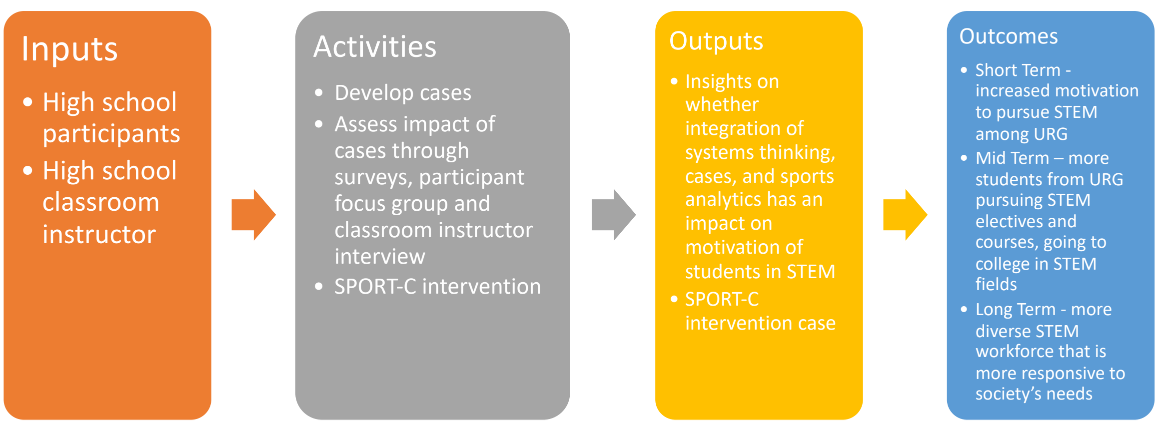

Figure 3 Logic model for study

The study's inputs and activities aim to realize the long-term outcome of a more diverse STEM workforce capable of responding more effectively to society's needs by connecting the left and right sides of the logic model. The long-term goal is to provide an educational environment that is relevant to the URG student population. The educational context in this work aspires to link learning to students' widespread interest in sports. Sports cases combined with systems thinking learning connects students to a topic they can relate to while also embracing the complexities of real-world work in the growing STEM field. The impact of these cases on the motivation of students from URGs to pursue STEM is one of the short-term outcomes that pave the way for middle- and long-term outcomes. Data is collected and analyzed throughout the process to answer research questions about the impact of sports, case frameworks, and systems thinking problem-solving methods on student motivation.

Positionality Statement

To begin this conversation, it is helpful to understand the author's positionality and the lens they are viewing the data. The sole researcher is an African-American U.S.-born scholar with immigrant parents from Ghana. The researcher is a 2nd year Master's student studying systems engineering at a university with a predominately white student body and faculty. They earned their bachelor's degree in mechanical engineering from a different university with a predominately white student body and faculty. The researcher serves as a contracted quantitative and qualitative researcher for the Sports Analytic Club Program (SACP), whose mission is to advance STEM education in the U.S. and promote STEM relevant professional careers for young women and men, driving sports as the educational platform. As a researcher, his role is to help incorporate sports cases into the classroom curriculum of a high school located in the South of the U.S. Prior work with SACP informed and influenced the design of this study. It is likely that the racial background of the author may have influenced the interpretations and implications of the study. The author had an external audit conducted on research to evaluate the accuracy and whether or not the findings, interpretations, and conclusions are supported by the data to mitigate the influence of the author's background and provide reflexivity to the study (Lincoln & Guba, 1985).

Methods

Study Design

A triangulation design, a mixed methodology approach, was used to understand the motivation levels of high school students. This mixed-methods approach allows for collecting different but complementary data on the research topic (Creswell & Clark, 2011). The results were consolidated using a convergence model in which quantitative and qualitative data were collected and analyzed separately, and results were also compared and contrasted.

The study's design was heavily informed by the researcher's prior experience developing sports cases to be integrated with a classroom curriculum while working with the SACP. The researcher was tasked with developing sports cases that could be incorporated into an already established classroom curriculum. In addition, the researcher was to report out the influence of the activities on the learning experience of the participating students to determine its viability for widespread school integration.

The researcher learned it was essential for instructor "buy-in," i.e., support to ensure an efficient activity development process. Prolonged activity development was experienced when the participating CIs were not fully engaged in the development process of the activity. CIs would, at times, become unresponsive to communications and delayed in producing necessary items for design progression. To increase CI support, at the beginning of each new activity development an initial goal alignment meeting was had to ensure that all major components of activity were discussed and a plan for activity implementation was laid out. This helped ensure that the CI understood the vitality of their role in activities' effectiveness and that the activity was tailored to a classroom flow they were accustomed to.

Institutional Review Board Considerations

Before data collection, Institutional Review Board (IRB) approval was obtained from the university IRB (protocol #4946). Due to the nature of the proposed study, the researcher applied for exempt review status; the current study posed no more than a minor risk to the study participants. Throughout the study, all of the IRB's guidelines were followed.

Data Collection

The participants in this study were students at a public high school in the southeast region of the United States. The high school hosts grades 9 -12 and has a 12:1 student-teacher ratio with under 1200 students. The school has a demographic breakdown of 50.7% ORG enrollment (44.5% white and 6.2% Asian) and 49.3% URG (28.7% Black, 13.6% Hispanic, 7.0% two or more races, Native American or American Indian and Hawaiian and Pacific Islander not reported) with 51% identifying as male and 49% identify as female (Virgina.gov, 2022). On Monday, students attend all classes they are enrolled in for fifty minutes each. Tuesday through Friday, students alternate taking their even and odd day classes, each with a length of an hour and twenty-five minutes. Participants were all enrolled in a multi-grade level math class, “Algebra, Function, and Data Analysis” (AFDA). Participants for the study were selected based on their class period. The control group was pulled from 11 students who attended Period 3 AFDA on Mondays from 10:50 to 11:35 AM, Wednesdays and Fridays from 10:45 AM to 12:50 PM, with a 30-minute lunch break between 12:20 and 12:50 PM. The intervention group was pulled from 21 students who attended Period 6 AFDA, which was held on Mondays from 2:15 to 3:00 PM and Tuesdays and Thursdays from 2:25 to 3:55 PM. Parental consent was given because the participants were minors; see Appendix A. Participants were also given assent forms at the start of the study; see Appendix B. Participants in this study volunteered and were not compensated for their participation. Race, gender, and school grade level were all collected; see Appendix C.

The study was conducted in March 2022, and Covid-19 cases were still prevalent in the area; however, the class was still held in person. As noted by the CI, class attendance was inconsistent due to the school policy for students to remain at home if experiencing any COVID-like symptoms. The study began with 15 participants, 11 from the experimental group and four from the control. Only 10 participants completed the study due to unavailability: three from the control group and seven from the experimental group. The breakdown of the participant pool is shown in Table 1.

Table 1 Breakdown of participant pool

Participant ID	Gender	Race	Grade	Group (Intervention or Control)	Focus Group (Y/N)
Apple	Male	Black/African-American	11th	Intervention	Y
Bear	Male	White	10th	Intervention	N
Blue	Male	White	12th	Control	N
Horse	Female	Black/African-American	11th	Intervention	Y
Lion	Prefer not to answer	Black/African-American	11th	Intervention	N
Orange	Male	Black/African-American	11th	Intervention	N
Peacock	Female	Black/African-American	11th	Intervention	N
Red	Female	Some other race or more than one race	10th	Control	N
Spider	Female	Native Hawaiian or Other Pacific Islander	11th	Intervention	Y
Yellow	Male	Black/African-American	10th	Control	N

Procedure

Figure 4 showcases a timeline of the study. Before receiving any study material, the participants all engaged in the same classroom lesson administered by the same CI on using probability to calculate expected values during their respective class periods. At the end of their respective lessons, both intervention and control groups received their respective pre-surveys on Thursday and Friday, respectively; see Appendix D and E.

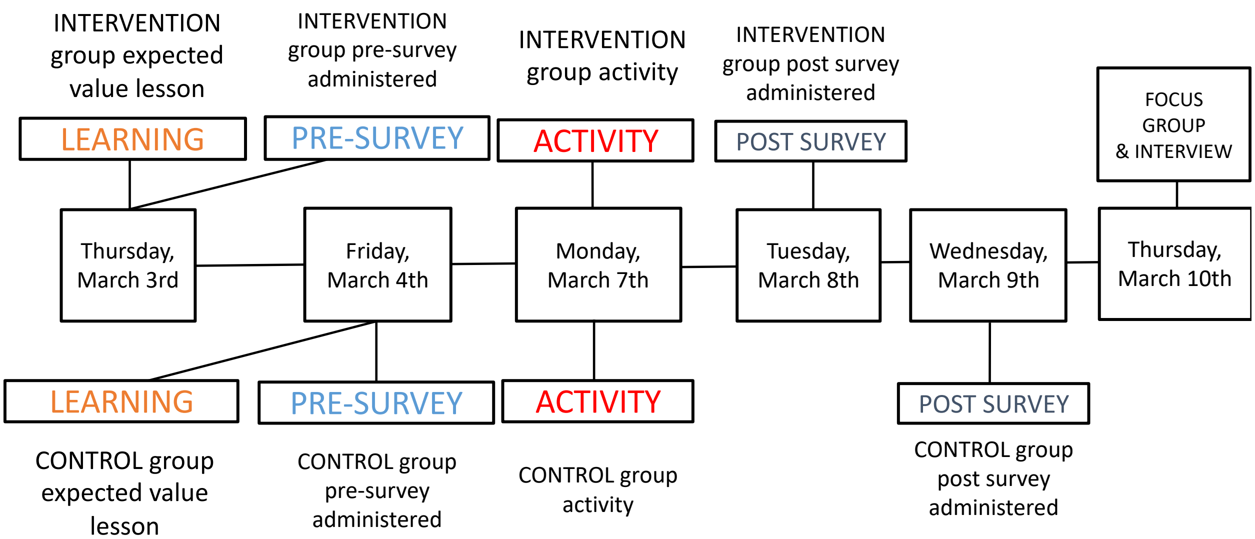

Figure 4 Study timeline

The following Monday, both groups received their activity. After completing the activity, the participants from both groups were asked to complete a post-activity survey. The post-activity survey was the same as the control group pre-survey. Participants from both groups completed the post-survey the class period following their activity day due to running out of class time. Focus group participants were gathered and interviewed two class periods, or three days, after the intervention activity.

Intervention Activity

Participants were exposed to the SPORT-C intervention activity in the intervention group (see Appendix F). The researcher designed and prepared the SPORT-C intervention in collaboration with the classroom teacher to ensure that the lessons learned were comparable to those learned by the control group. The intervention was developed so that no special or external training would be required of the CI. The SPORT-C intervention activity involved the participants using probability and expected values to solve a scenario that could present itself in the basketball world. Basketball was specifically chosen as the activity due to the familiarity with the sport by the CI, and the instructor felt that a specific basketball scenario would coincide well with their current lesson plans. Choosing basketball as a topic further reinforced the cultural relevancy of the intervention activity. The study was conducted during March coinciding with March Madness, a widely known college basketball tournament. A significant component of the study was to ensure that the proposed implementation activity meshed well with the instructor’s teaching style and class structure. The activity began with a warmup section in which students were refreshed on how to use probabilities to calculate expected values. The warmup section also provided a brief introduction to concepts that would be useful to know while completing the activity, such as the point value for a shot attempt and how the expected value would be calculated for different shot types. In the scenario, participants were asked to determine which player on the opposing team they should foul to avoid losing a close game in the final seconds. Participants were to base their decision on their calculated expected value of a player’s made field goal, free throw, or three-point attempt by the opposing team's final lineup. Participants were taken through the systems thinking approach of breaking down and redefining the problem, noting what assumptions they were to make, and identifying data they might need to solve the problem adequately. Afterward, participants needed to use their learnings from their previous class session to perform their data analysis. Participants had to calculate expected values for each shot type based on the season stats of the remaining five players. Lastly, participants were asked to provide a recommendation to the coaching staff, using their data analysis results as justification.

Control Group Activity

The control group participated in their scheduled non-sports related classroom activity (see Appendix G). The control activity had no central theme. Participants were asked to calculate the expected value for investment portfolio's, various games involving probability, and ticket sales. The CI allowed participants in each group to work in groups of three.

Survey Development

A 40-item survey was used to gather quantitative data on the participant's motivation levels before and after the respective activities. The survey asked five questions about students' academic engagement, 12 questions about self-efficacy, three questions about expectancy, three questions about values, four questions about the cost of STEM courses, and 13 demographic questions. Surveys were administered via Qualtrics. Participants were allowed to skip any question and stop the survey at any time. Both the pre and post-survey were administered during class time. Both groups received the same surveys, except the intervention group survey asked for volunteers to participate in a post-intervention focus group.

A series of validated survey scales were utilized to construct the entirety of the survey and then administered to participants. For instrument reliability, chosen scales had a minimum Cronbach α or McDonald's ω of .7 or higher (Streiner, 2003). Each scale is discussed in further depth in Table 2. The CI gave each participant an identifier for the researcher to match pre- and post-survey results. The researcher was not provided a list of identifiers and corresponding student names for confidentiality purposes.

Table 2 Subscales used in survey development

Academic Engagement	The five-item scale was adapted from Leibowitz et. al (2020). In the study, Leibowitz et. al found the Cronbach α to equal .781, meeting our minimum requirement. Each item was rated on a five-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neither agree or disagree, 4 = Agree, 5 = Strongly Agree).
Self-Efficacy	The twelve-item scale was adapted from Luo et. al (2020). In the study Luo et. al found the Cronbach α to equal .90, meeting our minimum requirement. Each item was rated on a five-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neither agree or disagree, 4 = Agree, 5 = Strongly Agree).
Expectancy	The three-item scale was adapted from Kosovich et al. (2015). In the study Kosovich et al. found the McDonald's ω to equal .88, meeting our minimum requirement. Each item was rated on a seven-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neither agree or disagree, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree).
Value	The three-item scale was adapted from Kosovich et al. (2015). In the study Kosovich et al. found the McDonald's ω to equal .84, meeting our minimum requirement. Each item was rated on a seven-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neither agree or disagree, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree).
Cost	The four-item scale was adapted from Kosovich et al. (2015). In the study Kosovich et al. found the McDonald's ω to equal .86, meeting our minimum requirement. Each item was rated on a seven-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neither agree or disagree, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree).

Focus Group

A focus group was formed to encourage participants to share their individual experiences about the intervention activity holistically. Only participants from the experimental group were recruited to participate in a follow-up focus group. Any participation from control group participants would not have been advantageous for analysis as they were not exposed to the intervention activity. The focus group consisted of three participants. Initially, four had volunteered to participate; however, only three were present on the session day. A semi-structured interview was conducted via Zoom. Participants were asked questions ranging from what they liked and disliked about the activity, what they would change if given the opportunity, and the sports topic's impact on their learning experience. A full list of interview questions can be found in Appendix H. The interview was scheduled for 25 minutes, but it took approximately 30 minutes to complete. The participants and the researcher met over a Zoom call with a school chaperone present. Participants gathered in separate locations at their school library and logged in to the Zoom call. The chaperone did not participate during the interview and was only present as a safety measure taken by the school. The participants were asked to change their display name to an assigned title, such as "Participant 1," "Participant 2," etc. The researcher did not track the assigned display name. Participants were allowed to skip any questions that made them uncomfortable and had the opportunity to stop the focus group. Audio recordings were stored on password-protected computers at UVA. Only the researcher had access to these audio recordings. In addition, the researcher took typed notes during the focus group and read direct quotes back to the participants for clarification. Any quotes pulled from the focus groups were anonymized.

Classroom Instructor Interview

The CI interview was conducted to provide qualitative data on the participants' engagement from the instructor's perspective. This provided the study with insight into the perceived effectiveness from the instructor's lens and data on the progression of the activity during its dissemination. The interview was a ten-minute recorded Zoom call in which the instructor was asked questions about the participant's engagement with the intervention activity and the instructor's teaching experience with the intervention. Audio recordings were stored on password-protected computers at UVA. Therefore, only the researcher had access to these audio recordings. In addition, the researcher took typed notes during the interview and read direct quotes back to the

CI for clarification. Any quotes pulled from the interview were anonymized. A full list of interview questions can be found in Appendix I.

Data Analysis Procedure

To perform any quantitative analysis on the survey responses, matching the responses were required. The matching process of pre-and post-surveys required the matching of the student identifiers. Any responses with more than two missing items from a subscale had their subscale removed from the analysis. All data analysis was completed using SPSS software. First, pre and post-survey subscale scores were calculated by averaging Likert responses for each factor. Then, repeated multivariate ANOVA tests on the mean subscale scores were performed to evaluate any significant difference in the participant factor levels between the pre- and post-survey and baseline equivalence.

A grounded theory method for the coding process was invoked to perform qualitative analysis on the focus group and CI interview (Birks & Mills, 2011). The audio transcription, generated via Zoom's audio transcription feature, from both sessions was coded using inductive or open coding via the Dedoose software. The coding process and analysis were completed in four cycles for each session, and an analytical memo was developed for each as well. The first cycle of coding was an initial read of the transcription. The second cycle examined the transcription for codes using open coding (Birks & Mills, 2011). The third cycle looked for more codes while examining which codes appeared to be redundant or rarely applicable in the transcription. The fourth cycle was applying the codes developed during the previous cycles. During this cycle, the researcher decided whether the codes that were used the least should remain or should be renamed under another code. Using axial coding, the researcher drew connections between codes developed during the cycles, chunking the smaller pieces of coded text into themes/categories that were linked with some relation amongst them. Upon doing so, the researcher found several related codes that could be collapsed into broader codes, and codes that could be deleted from the codebook. Using the Dedoose software, the researcher examined whether the codes were used in each of the transcripts and how often they were used across the project. The codes developed from axial coding served as the broader themes/categories later discussed.

Results

Quantitative Results

Before to beginning the analyses, the researcher computed a new variable, race. Race was recoded using participant responses for ethnicity and race. Participants received a one if they responded “No” for “Are you Hispanic or Latino/Latina?” and responded either “White” or “Asian” for “Please select one or more of the following choices to best describe your race.” Participants received a two if they responded “Yes” for “Are you Hispanic or Latino/Latina?” or “No” but responded either “Black/African American” or “Native Hawaiian or Other Pacific Islander” or “American Indian or Alaska Native”. The newly computed variable was used in the subsequent analyses.

To answer both RQ1 and RQ2, a repeated measures multifactor ANOVA test was conducted to measure a relationship between the intervention activity and participant motivation levels. The dependent variable for the analysis was the mean scores for participant response to subscales. The average subscale score for participants pre- and post-survey (time) and their condition (intervention or control group) were used as the independent variables. The sample size was too small to generate adequate study power. Due to incomplete survey responses, some analyses for EXP, VAL, and COS subscales were unable to be performed by the researcher. Further discussion of study limitations is in later sections.

Academic Engagement. Table 3 showcases the descriptive statistics for the AE subscale responses for both URGs and OGs in both conditions before and after the intervention activity. Positive trends are seen in AE for URGs and OGs in the intervention group. There is no statistically significant interaction between time and condition, $F(1,6) = .449$, $p = .528$ or time, condition, and race, $F(1,6) = .315$, $p = .595$.

Table 3 Repeated measures ANOVA results for academic engagement, time, race, and condition

	Control						Experimental					
	Overrepresented			Underrepresented			Overrepresented			Underrepresented		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N
AE Pre	3.00	-	1	3.00	.283	2	1.60	-	1	3.39	1.26	6
AE Post	2.40	-	1	3.40	.283	2	2.60	-	1	3.93	.589	6

Seen in Figure 5, from the plot there appears to be an interaction between the condition and AE of participants before and after intervention when race is not taken into account. However, this interaction was not found to be statistically significant, $F(1,8) = .306$, $p = .595$.

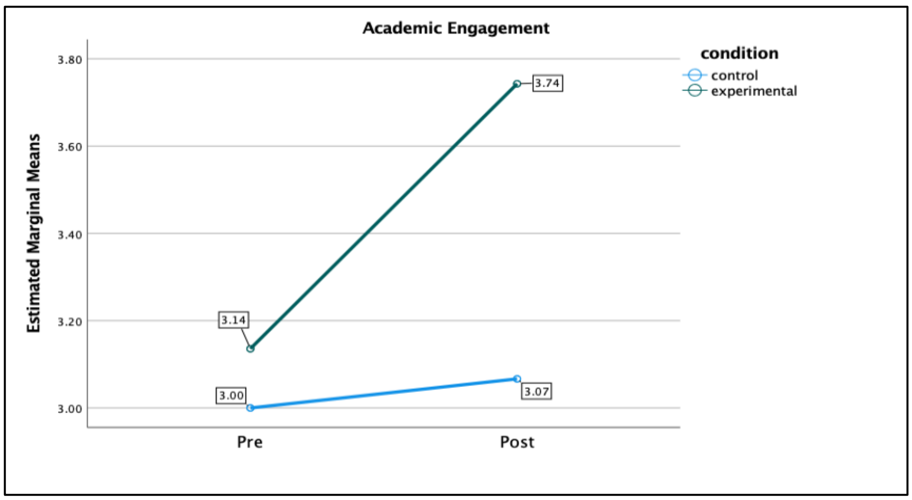

Figure 5 Interaction plot of repeated measures ANOVA results for academic engagement, time and condition

Self-Efficacy. Table 4 showcases the descriptive statistics for the SE subscale responses for both URGs and OGs in both conditions before and after the intervention activity. Positive trends are seen in SE for URGs in the intervention group, however the intervention appears to have a negative effect on OGs. There is no statistically significant interaction between time and condition, $F(1,6) = .245$, $p = .638$, or time, condition, and race, $F(1,6) = 1.297$, $p = .298$.

Table 4 Repeated measures ANOVA results for self efficacy incorporating, time, race, and condition

	Control						Intervention					
	Overrepresented			Underrepresented			Overrepresented			Underrepresented		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N
SE Pre	3.25	-	1	3.29	.059	2	3.73	-	1	4.07	.470	6
SE Post	3.50	-	1	3.21	.530	2	3.58	-	1	4.14	.466	6

Seen in Figure 6, there appears to be no interaction between the condition and SE of participants before and after intervention when race is not taken into account. The interaction was not found to be statistically significant, $F(1,8) = .005$, $p = .947$.

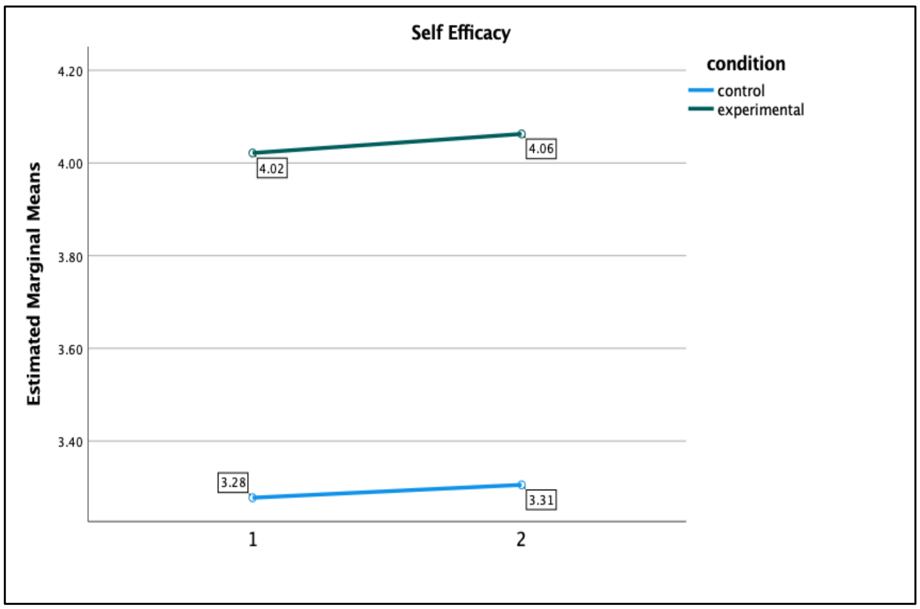

Figure 6 Interaction plot of repeated measures ANOVA results for self-efficacy, time and condition

Expectancy. Table 5 showcases the descriptive statistics for the EXP subscale responses for both URGs and OGs in both conditions before and after the intervention activity. Positive trends are seen in EXP for URGs on OGs in the intervention group. There is no statistically significant interaction between time and condition, $F(1,5) = .172$, $p = .696$.

Table 5 Repeated measures ANOVA results for expectancy incorporating, time, race, and condition

	Control						Intervention					
	Overrepresented			Underrepresented			Overrepresented			Underrepresented		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N
EXP Pre	4.00	-	1	5.00	.471	2	-	-	-	5.60	.894	5
EXP Post	4.67	-	1	5.50	2.59	2	-	-	-	5.80	.988	5

Seen in Figure 7, there appears to be a slight interaction between the condition and EXP of participants before and after intervention when race is not taken into account. The interaction however was not found to be statistically significant, $F(1,6) = .378$, $p = .561$.

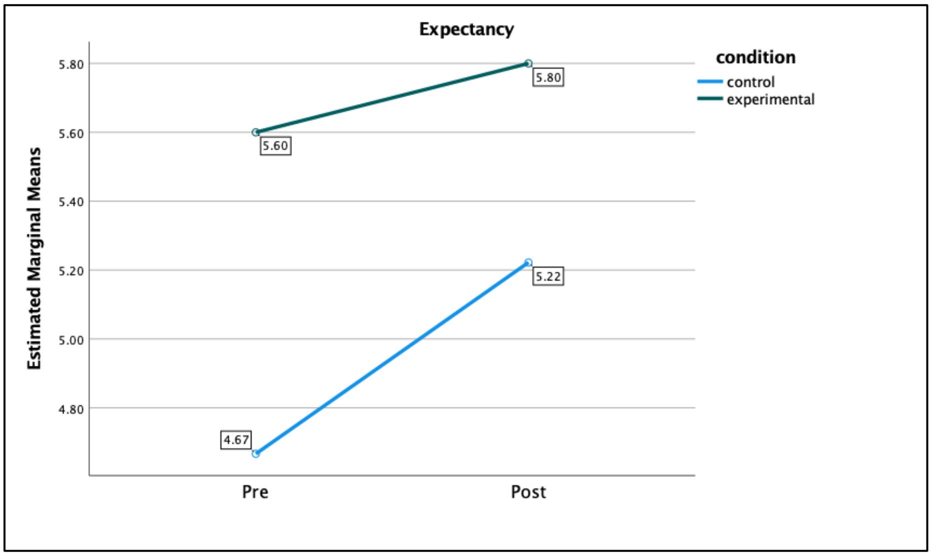

Figure 7 Interaction plot of repeated measures ANOVA results for expectancy, time and condition

Value. Table 6 showcases the descriptive statistics for the VAL subscale responses for both URGs and OGs in both conditions before and after the intervention activity. Positive trends are seen in VAL for URGs in the control group however there appears to be a negative trend in intervention group. There is no statistically significant interaction between time and condition, $F(1,5) = .586$, $p = .478$.

Table 6 Repeated measures ANOVA results for value incorporating, time, race, and condition

	Control						Intervention					
	Overrepresented			Underrepresented			Overrepresented			Underrepresented		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N
VAL Pre	2.67	-	1	3.67	.471	2	-	-	-	6.07	.796	5
VAL Post	2.00	-	1	4.00	0.00	2	-	-	-	5.87	1.22	5

Seen in Figure 8, there appears to be a slight interaction between the condition and VAL of participants before and after intervention when race is not taken into account. The interaction however was not found to be statistically significant, $F(1,6) = .109$, $p = .753$.

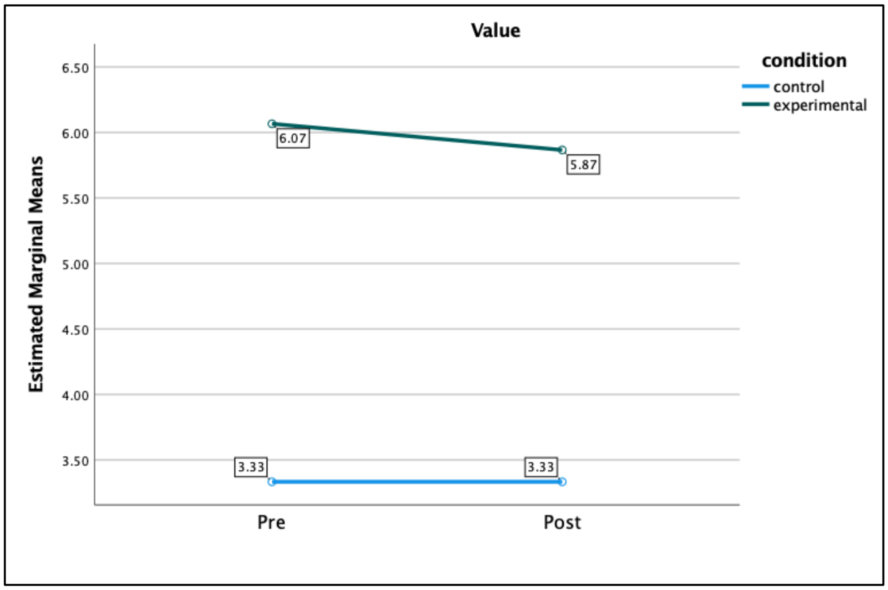

Figure 8 Interaction plot of repeated measures ANOVA results for value, time and condition

Cost. Table 7 showcases the descriptive statistics for the COS subscale responses for both URGs and OGs in both conditions before and after the intervention activity. Positive trends are seen in COS for URGs in both the intervention and control group. There is no statistically significant interaction between time and condition, $F(1,5) = .051$, $p = .831$.

Table 7 Repeated measures ANOVA results for cost incorporating, time, race, and condition

	Control						Intervention					
	Overrepresented			Underrepresented			Overrepresented			Underrepresented		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N
COS Pre	3.75	-	1	4.13	.177	2	-	-	-	5.35	.802	5
COS Post	3.75	-	1	3.63	.530	2	-	-	-	4.45	2.02	5

Seen in Figure 9, there appears to be an interaction between the condition and COS of participants before and after intervention when race is not taken into account. The interaction however was not found to be statistically significant, $F(1,6) = .172$, $p = .693$.

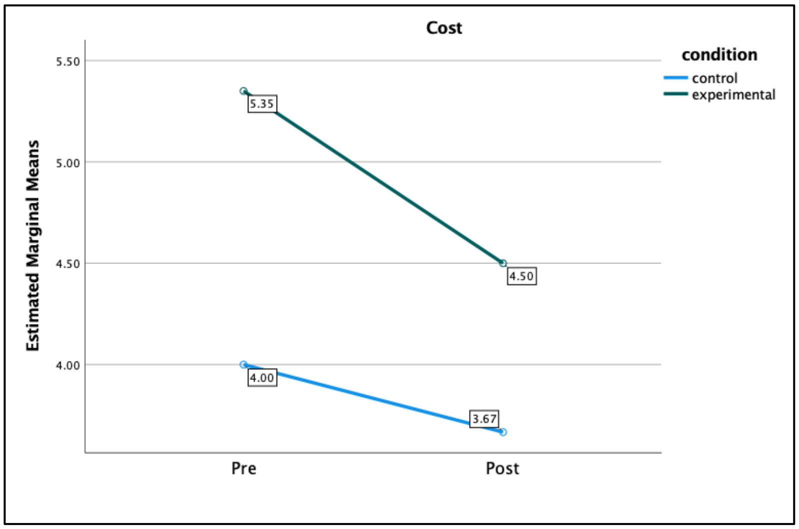

Figure 9 Interaction plot of repeated measures ANOVA results for cost, time and condition

A summary of the difference in mean values from pre- to post-survey responses in both the control and intervention groups by the racial group is shown in Table 8. Green shaded boxes indicate a positive difference in mean values relative to scales, and red shaded boxes indicate a negative change. White boxes indicate no change.

Table 8 Mean value differences for subscales

	Control		Intervention	
	Overrepresented	Underrepresented	Overrepresented	Underrepresented
Academic Engagement	-0.60	0.40	1.00	0.54
Self-Efficacy	0.25	-0.08	-0.15	0.07
Expectancy	0.67	0.50	-	-0.10
Value	-0.67	0.33	-	-0.51
Cost	0.00	-0.50	-	-0.93

Baseline Equivalence. To determine if each participant pool was appropriate for comparison, a baseline equivalence test was performed. A multifactor ANOVA test was performed on the mean of each subscale. The independent variable were the control and intervention groups, the dependent variable the mean of each subscale. Table 9 displays the p-values for each test. The self-efficacy and value subscales were the only subscales to output a significant difference between the experiment and control group.

Table 9 Baseline equivalence results

	p-value
Academic Engagement	.392
Self-Efficacy	.027
Expectancy	.274
Value	.007
Cost	.161

Qualitative Results

The following sections are organized by the broader themes/categories developed during the coding phase. Over the six final codes and subcodes developed, three themes emerged: learning experience, structure, and relevancy.

Theme 1 – Learning experience. The main objective of the focus group was to provide the participants with another opportunity to share their experiences while participating in the SPORT-C intervention activity and address RQ1. Within this theme, three codes are included that pertain specifically to the participant's experience: activity engagement, activity difficulty, and activity comprehension.

Both the participants and the CI expressed levels of engagement higher than the norm. Participants stated several times that they felt more engaged while participating in the activity. For example, participant 2 said, "I was actually paying attention in class for once which is rare for me" and they "…didn't zone out completely". Their responses are echoed by the CI as they mentioned the students "…definitely seemed interested" and that "…everybody was pretty engaged, even the kids that are usually little harder to get involved they seemed like they all put their head down and got their work done." The CI went as far as to mention that two students in particular that require a bit of their attention to get engaged with the classwork "seem[ed] to do pretty well the whole time". There was no mention of disinterest from the students or the CI.

There was a mixture of responses regarding the activity difficulty for the participants. Participants all agreed that the format of the SPORT-C intervention made it easier for them to complete the assignment. Multiple participants stated that the assignments were easy but posed a challenge for them. Participant 1 voiced the "roller coaster ride" of difficulty stating, "For this worksheet I felt as if it was hard to get, of course, because [it was] something new, but as time went on it got easier, but then also got harder again, but then it got easier, you know it wasn't just consistent with how hard it was getting...". This "roller coaster" ride was coupled with a sense of accomplishment later discussed. It is also key to note that Participant 1, in particular, expressed that their only disgruntle with the SPORT-C intervention was its difficulty level in the beginning, stating, "I didn't really have much complaints aside from the starting factor of how hard it was at first until it just got easier."

All three participants echoed that they could comprehend what they were working on. Participant 1 notably stated that “[I] felt like I was actually like understanding some of the things that I was actually working on” while comparing the SPORT-C intervention to the classroom’s routine activities. Participant 3 stated some confusion during the expected value lesson before the intervention activity. They later gained understanding after the intervention activity was implemented stating, “For me [it] was good [as] basketball is my favorite sport and to use it [it] make more sense for me to do because before we started it was very hard [but] like when he explained to us I understand a lot of what he was doing”. The participants expressed more confidence in their ability to do and complete the intervention activity. Participant 2 reflected upon his experience while completing the intervention activity, “You know I learned a few things by myself, even though I got stuck really on most a lot of places, but [as] it just gradually went through my head I collected myself, and you know I just push[ed] through without any help at all, which you know I actually you know I really loved about it to be honest.”

Theme 2 – Structure. A prominent topic of discussion was the overall structure of the SPORT-C intervention. The structure does not address RQ1 however provides the researcher insights into the reception of the intervention for future iterations. Participants frequently mentioned their feelings on the structure compared to their normal classroom flow. All students preferred the SPORT-C intervention over the normal classroom flow as “[it] just felt more put together,” stated participant 1 several times. Participants 2 and 3 took to the structure of SPORT-C intervention as they appreciated the guidance provided by the CI throughout its entirety. After stating earlier in the focus group that they were "more of an independent worker kind of person" who tended to "rush ahead" during assignments, Participant 1 stated that structure allowed them to work independently while remaining attentive to the CI's guidance, something they would not have done previously. The CI, during their interview, stated that “the activity was great and well put together.”

Theme 3 – Relevancy. This theme relates to RQ1 as relevancy is correlated with value and can influence student motivation if present. Participants expressed being able to make connections “quicker” as the topic was something they were all familiar with. For example, regarding basketball, participant 1 stated, "Like it was something real. I understand [the assignment] quicker because it's something you know that's like in our world and tangible and like is an actual something that a lot of people watch and participate in, so I think that just made the connection easier in my brain." Participant 2 echoed the same sentiment as being able to make "sense faster" due to both the topic and the structure of the intervention.

Discussion

The quantitative data was collected to help answer both RQ1 and RQ2, and the qualitative data was collected to help answer both RQ1 and RQ2, but due to the small sample size, the data has no statistical significance. While some of these results suggest that the intervention was beneficial, they must be viewed as preliminary and not generalizable.

The positive impact of the SPORT-C intervention on student motivation is worth noting. URGs saw positive trends in AE and COS; however, the same effect was seen in URGs in the condition group. The parallel results could be attributed to the consistency between both activities being centered around expectancy value.

It's interesting to see how URGs notice a downward trend in the intervention group's EXP and VAL subscale scores from pre- to post-survey, but a positive trend in the control group. Because both groups fail the baseline equivalence test for that subscale, there is no way to compare their VAL subscale score changes. Furthermore, the EXP subscale score difference is negligible at 0.10 and of no concern due to the insignificance of the values. The increased AE corresponds to the CI and focus group responses. There was general agreement that there was a higher level of engagement while participating in the activity. Participants noticed changes in their usual behavior and the CI in their students due to the SPORT-C intervention. The intervention did not require any additional motivation from normally disengaged participants or required special attention. Some participants who would normally require the CI's assistance to jumpstart classwork did not require it during the intervention activity, surprising the CI.

It's worth noting that URGs in the intervention group saw a reduction in cost. This indicates that the participants did not view the intervention activity as a waste of time. The intervention activity was not viewed as a time-consuming activity by the participants. This finding coincides with the focus group's assessment of the activity's difficulty and participation. The participants stated that completing the task was difficult at first. It's natural for students to avoid work that becomes too difficult. However, as one participant pointed out, the intervention's difficulty only encouraged them to try harder. The participant's perception of the activity's difficulty prompted them to work harder on the assignment and overcome the challenge. The participant finished the activity with pride in their ability to complete it. As a result of the intervention, the students' self-efficacy and expectancy in STEM activities increased. The difficulty was not included in the activity on purpose, but it is something to keep in mind for future iterations. The students sacrificed more time to complete the activity as they put more effort into it. They were rewarded with a sense of accomplishment despite putting in more time than usual to complete the activity. This tradeoff is reflected in the participant's cost response.

It was expected that choosing to put more time in an activity rather than giving up would result in a greater sense of value. The quantitative results, however, do not reflect this. As the average subscale scores drop, the negative VAL subscale score trend for URGs in the intervention is of interest. After the intervention, URGs place a lower value on STEM education. Because of the small sample size, this could simply be due to participants' responses changing, which would significantly impact the average subscale score. The quantitative results contradict that of the focus group responses. For one participant in particular, the intervention activity allowed for easier comprehension of the topic in terms they were familiar with. The literature backs these findings as a culturally relevant pedagogy that can lead to academic success, in this case, in the form of understanding (Ladson-Billings, 1995, 2014; Ladson-Billings, 2009). The participant could connect the learnings from the activity to experiences outside the classroom. This connection adds value to the educational context, which influences their motivation to participate in the activities.

All participants mentioned their affinity for the structure of the intervention. According to the participants and the CI the intervention was well-designed. The participants preferred the structured intervention over their usual learning activities as it allowed for a more engaging learning experience with the CI. The students were able to ask questions, spark discussion amongst one another as they progressed through the activity. The intervention’s case-based pedagogy resulted fostered active learning as participants became more engaged in the learning process amongst themselves and the CI, echoed in the literature (Freeman et al., 2014).

To answer RQ1, the SPORT-C impacts student motivation to participate in STEM courses, based on focus group responses. Because the ORG intervention group did not respond to the EXP, VAL, or COS subscales, the answer to RQ2 is based solely on a non-generalizable interpretation of the AE and SE subscale scores. Because the study did not have an adequate sample size and the focus group participants were de-identified, the answer to RQ2 is inconclusive.

Implications

Although the study was limited to one high school math class, the findings suggest that the SPORT-C intervention has an impact on students' STEM motivation. When applied to a larger group of students, the intervention's impact on students can be significant. The CI was able to elicit participation from students who were previously uninterested. Because the framework is adaptable to virtually any STEM course, the SPORT-C intervention can be expanded to different STEM curriculums. A shift in motivation seen in those students by the CI could potentially be replicated in other classrooms with other CIs and their less engaged students after adopting the framework.

Each component of the SPORT-C intervention has been shown to be effective in a variety of high school age groups, so it is not limited to one age group. The SPORT-C intervention's adaptability and widespread applicability could greatly impact young people's interest in STEM classes and careers. Engaging URGs at an early stage should increase their participation in STEM courses and serve as a springboard for increased representation in the STEM workforce.

During the focus group, the participants frequently mentioned how much they enjoyed the activity's structure. The students were able to address each component of the case in a digestible manner thanks to the embedded systems thinking problem solving flow. The participants expressed how the flow of the activity aided in their comprehension of the material and altered their normal classroom participation patterns. This increased engagement, reflected also in the surveys, implies that the intervention activity can be a tool used to bring a classroom activity framework that not only helps in the student’ comprehension of materials but also fosters classroom participation that is productive to learning experience of all students.

The activity's difficulty level was also mentioned several times during the focus group. The participants felt accomplished after completing the perceived difficult tasks. This achievement resulted in higher levels of self-efficacy and expectancy. The difficulty stemmed primarily from the unfamiliarity with the case format, but the CI and participants both echoed that it had no negative impact on students. This indicates that the intervention framework posed a challenge for the students to overcome. However, the fact that they could overcome the obstacle had a positive impact on their motivation levels. This implies that students appreciate a challenge when it comes to their classwork and are willing to “step up to the plate”.

Limitations

There were a few drawbacks to this study. While the study was conducted in March 2022, COVID-19 cases were still prevalent in the study area, particularly in schools. This resulted in a participant pool with erratic and inconsistent attendance in the classroom. Due to school policies requiring students to stay at home if they were experiencing any symptoms, the pool size was significantly reduced. The study may have missed out on profound effects on racial demographics due to the sample size. If statistical significance were present, a larger sample size would have resulted in a larger study power size, and a statistical significance would have been observed in the quantitative analysis if one existed. The study was also hampered by heavy attrition due to COVID-related absences, as the participant pool shrank to just a few people in each group throughout its course.

Another limitation is that the study only included students enrolled in AFDA classes. Because participants could not be chosen randomly, they were chosen from a pre-assigned class. Based on their class section, they were split into the intervention or control group. This determined whether they were given a control or intervention activity, directly impacting the study's randomization factor, crucial for internal validity.

Participant data fails to capture all members who are URG and ORG. All members who are URG and ORG are not captured in the participant data. Only Black/African American and Native Hawaiian participants are included in the URG data. ORG data only includes White participants. Obtaining knowledge of classroom demographic was limited to students who volunteered to participate in the study. There is no way of knowing if the classroom is representative of the school's student body or the average U.S. classroom.

The activity and post-survey should have been completed on the same day to collect accurate data on the intervention's post-effects on participant motivation levels. The post-survey was completed days later due to a lack of time in class, affecting the capture of the intervention activity's effect on motivation levels while completing the intervention activity. If students completed the post-survey at the end of the class period, their responses would be a more accurate representation of the activity's effect on their motivation. Uncontrollable factors, such as other classroom experiences, could have influenced students' responses between the end of the activity and their response to the survey.

Participants left some scale responses blank on their surveys, affecting the already small sample size used for quantitative analysis. The goal of the focus group was to gather qualitative data to back up the hypothesis that the SPORT-C intervention differed by race. Due to IRB restrictions, the focus group participants were anonymous, affecting the researcher's response to RQ2. IRB approval for future studies should allow for the analysis of racial identity.

Despite the fact that the COVID-19 pandemic posed a constraint, the focus group was held to capture the entirety of the participants' learning experience. Zoom was used to conduct the focus group. Because some participants were unresponsive at times and did not have their cameras on during portions of the study, an in-person focus group would have resulted in a more interactive session.

Recommendations for Future Works

The findings from this study bode well for a follow-up. However, a few steps are to be taken if the SPORT-C intervention were implemented and tested in another classroom setting.

According to the National Center for Education Statistics, URGs account for 43% of school demographics, while ORGs account for 52% (National Center for Education Statistics, 2021). In comparison to the general population of the United States, the population I drew from is fairly diverse. The study's goal was to focus on the effects on specific racial groups, but a study that represented the entire country's population would be more suitable for the generalizability of the findings. Before interacting with a school system, it might be best to wait for COVID-19 cases to subside and cases to die down. The school's COVID-19 protocol directly impacted attendance, affecting the availability of participants in both the control and intervention groups.

A larger sample size would be required to ensure that statistical significance in the quantitative results could be detected if one existed. A large sample size could result in a participant pool that includes participants from all desired demographics. Accessibility also must be considered when the study is scaled up. Because the SPORT-C intervention necessitates a substantial amount of reading, future designs should consider how to mitigate cognitive disabilities like dyslexia and other special needs components. The topic of the sport and its familiarity with the participant pool would also have to be considered in the design. In the hopes of a global application, sports that are unfamiliar in the intervention activity's region of application may cause a disconnect from students and the context of the activity. This could have a negative impact on the students as the sport would have little to no meaning in their lives.

While taking part in the study, participants may have experienced survey fatigue (Porter et al., 2004). As a result, a brief survey focusing on a single motivation factor, such as academic engagement or self-efficacy, would be best suited for measurement. This would enable the researcher to fine-tune the intervention activity, hopefully resulting in participants providing positive feedback on their learning experience.

The execution of the study plan was a limitation. The post-activity surveys and focus groups were not conducted right away after the participants finished the activity, and the focus group was not held until three days later. Uncontrollable factors may have influenced the post-survey due to the time gap between the intervention activity and the post-survey responses. Participants in the focus group stated that they had a hazy memory of the activity. The researcher decided to show the participants a brief overview of the activity during the focus group to help the participants remember the activity. This highlighted the impact of time on their responses. Future studies must ensure that enough time is allotted to complete the intervention activity and the post-survey in one class session to accurately capture the participants' motivation levels. It is also strongly recommended that the focus group be conducted shortly (within 48 hours) after the activity in future studies.

It would be interesting to look at the intersectionality of race and gender as impacted by the sport chosen. Intersectionality describes a framework for understanding how multiple intersecting social identities (e.g., sex, race or ethnicity, sexual orientation, disability, and class) affect life outcomes in ways that are qualitatively and quantitatively different from the impact of a single social identity (Cole, 2009). It would be interesting to test if there was a difference in motivation levels with the sport's topic being female sports, i.e., Women's National Basketball Association (WNBA), vs. male sports, i.e., National Basketball Association (NBA).

Another area for research is to see if the demographic of the sports topic has any bearing on the participants' motivation levels and racial identity. For example, the NBA (racial breakdown:

74.2 % African American, 2.2 % Hispanic, and 16.9 % White)[9] was used in the "Hack-a-Shaq" scenario (Gough, 2021). It would be interesting to see if a league like Major League Baseball (MLB) (racial breakdown: 78 % White, 7.2 % Hispanic, 6.8 % African-American, 3.9 % Asian, and 0.4 % American Indian)[10] has any impact on student engagement or value of STEM (Zippia, 2021). According to studies, a student's inability to visualize themselves in a field of study may impact their interest in STEM (DeWitt et al., 2014). Perhaps a sport in which a student is more widely represented positively affects their interest in that sport. The discovery of a connection could open the door to tailoring activities to the student, serving as a positive impact to the learning experience of students.

[9] Asian, American Indian and Alaska Native, Hawaiian or Other Pacific Islander not reported
[10] Hawaiian or Other Pacific Islander not reported

Conclusion

Through the innovative integration of sports and case-based systems thinking learning, this study proposed and tested an approach to addressing social inequity in STEM education. The SPORT-C intervention is a framework that combines sports, systems learning, and a case-based pedagogy into an activity that can be used in any STEM course. A pilot study was conducted to determine the viability of the SPORT-C intervention in a classroom setting to determine if it was worth further investigation and to see if any impact differed by racial identity. The findings from this study imply that the SPORT-C intervention impacts the motivation levels of students to participate in STEM courses, but no generalizable quantitative or qualitative data was produced. Participants reported higher levels of engagement, a sense of accomplishment from completing perceived complex tasks, a quicker grasp of the learning topic due to relevance, and a preference for the intervention's activity structure. The findings support the researcher's decision to continue investigating the interventions' impact on student's motivation to pursue STEM courses as means to diversify a field that isn't representative of the population it serves.

APPENDIX A

Parent/Guardian Informed Consent Agreement
Please read this consent agreement carefully before your child decides to participate in the study. Your child will also receive an assent form; please review the assent form with your child.

Purpose of the research study: We want to learn whether using examples involving sports and athletes will help your child better enjoy learning in science, technology, engineering, and math (STEM) concepts.

Sports has been a demonstrated unique approach to engaging students in STEM education. Linking STEM learning with a meaningful activity for many students has been shown to increase motivation levels in courses. In addition, sports are an inclusive background that can improve students' engagement of diverse backgrounds in STEM. It is necessary to incorporate STEM into activities they enjoy and already participate in, such as sports, to engage students in STEM.

Problem-solving requires the use of systems thinking. Systems thinking is a thought process in which a set of connected pieces with a common goal are analyzed to uncover hidden values and arrive at conclusions. The purpose of incorporating systems thinking into the classroom is to build on educational content while also connecting to a fast-growing STEM field. Problem-solving is an essential part of almost every career path, and those who are good at it will stand out among their peers. There is reason to believe that this linkage between sports, cases, and systems thinking will motivate students to pursue STEM careers.

What you will do in the study: During your child's "Algebra, Functions, and Data Analysis" class instruction, all participating students will partake in a classroom activity in the form of a sports analytics case. This case will complement the learning activity already scheduled in their class periods.

As part of our research, we would like to ask your child to complete two 5-minute anonymous surveys via Qualtrics. A pre-and post-survey will be administered to gather before and after interest levels in your child's STEM course. Your child may skip any question and can stop the survey at any point in time. The entire survey portion of the study should take no longer than 10 minutes and will occur during class time. If your child decides not to participate, their teacher will provide them with an alternative activity.

If your child chooses to, they may participate in a focus group after participating in the classroom activity. The focus groups will consist of 2-3 other students, more if available, to gather attitudes, feelings, beliefs, experiences, and reactions to the case activity. Your child will meet via Zoom for roughly 25 minutes to provide responses in a recorded session.

Time required: The study will require 1 classroom session, 2 if deemed necessary, and 25 minutes or less for a focus group. The surveys before and after case activity will take roughly 5 minutes each. In total, it will take no more than 35 minutes to complete the entire study.

Risks: Participating in this study will bring your child no harm. The case used in the study will be performed in conjunction with their teacher who will be fully engaged in planning and execution.

Benefits: There are no direct benefits to your child for participating in this research study. The study, on the other hand, may help us understand how sports analytic cases may affect your child's STEM motivation.

Data not linked to identifying information: *If your child chooses to participate in the surveys,* your child’s anonymous results will be stored via UVA’s computers, only accessible by the researcher. The information that your child gives to us will not have their name on it, so we won’t know what answers you give us. However, we may be able to figure out who your child is because of their answers, but we won’t try to do so. Results will be reported in aggregate; no individual data will be discussed.

Confidentiality cannot be guaranteed: *If your child chooses to participate in the focus group,* because they are in a focus group with other students, we can't guarantee that their information will be kept private. It may be possible that others will know what your child said. Only audio recordings will be used in research. Audio recordings will be stored on computers at UVA, and only the researcher will be able to listen to them. Any quotes pulled from the focus groups will be de-identified. During the Zoom call, your child will be asked to change the display name to an assigned title such as "Participant 1," "Participant 2," and so forth. The researcher will not keep track of your child's assigned name as an added means of providing privacy to your child. Any recordings will be destroyed after completion of analysis and submission of researcher's thesis, on May 1st, 2022.

Voluntary Participation: Your child's participation in the study is entirely voluntary. Your child's grades and school services will not be affected by their decision to participate in the study.

Right to withdraw from the study: Your child has the right to withdraw from the study at any time without penalty. However, because the surveys are anonymous, your child's submitted surveys cannot be withdrawn. If your child participates in the focus group interviews and chooses to stop before we are finished, any answers they already gave will be destroyed. Any transcription of your child's involvement in the focus will be destroyed should they decide to withdraw.

How to withdraw from the survey: If your child wants to stop doing the survey, they will have to close their browser and not submit the survey. There is no penalty for stopping.

How to withdraw from the focus group: If your child wants to stop during the focus group, have them tell Jeffrey Basoah. If they choose to stop before we are finished with focus group interviews, any answers they already gave will be destroyed. Understand that if they decide after the focus group is complete that they don't want their responses in the study, there is no way of identifying responses as your child's identity will not be linked. There is no penalty for stopping.

Using data beyond this study: The information your child provides in this study will be retained in a secure manner by the researcher for two months and then destroyed.

Payment: Your child will receive no payment for participating in the study.

If you have questions about the study, contact:
Researcher's Name: Jeffrey Basoah
Department of Engineering Systems and Environment, 151 Engineer's Way
University of Virginia, Charlottesville, VA 22903.
Telephone: (434) 924-5395
Email: jkb2jf@virginia.edu

Faculty Advisor's: Dr. William Scherer
Department of Engineering Systems and Environment, 151 Engineer's Way
University of Virginia, Charlottesville, VA 22903.
Telephone: (434) 982-2069

To obtain more information about the study, ask questions about the research procedures, express concerns about your participation, or report illness, injury or other problems, please contact:
Tonya R. Moon, Ph.D.,
Chair, Institutional Review Board for the Social and Behavioral Sciences
One Morton Dr Suite 500
University of Virginia, P.O. Box 800392
Charlottesville, VA 22908-0392

Telephone: (434) 924-5999
Email: irbsbshelp@virginia.edu
Website: https://research.virginia.edu/irb-sbs
Website for Participants: https://research.virginia.edu/research-participants
UVA IRB-SBS # 4946

Agreement:
I agree to allow my child to participate in the research study described above.

Print Name: ____ Date: _____________

Signature: ____

You will receive a copy of this form for your records.

APPENDIX B

Minor Informed Assent Agreement 13-17 (Survey)
Please read this assent agreement with your parent(s) or guardian(s) before you decide to participate in the study. Your parent or guardian will also give permission to let you participate in the study.

We want to learn whether using examples involving sports and athletes will help you better enjoy learning in science, technology, engineering, and math (STEM) concepts.

During your "Algebra, Functions, and Data Analysis" class instruction, all students will participate in a classroom activity in the form of a sports analytics case. This case will complement the learning activity already scheduled in one or two class periods.

As part of our research, we would like to ask you to complete two 5-minute anonymous surveys via Qualtrics. A pre-and post-survey will be administered to gather before and after interest levels in your STEM course. You may skip any question and stop the survey at any time. The entire survey portion of the study should take no longer than 10 minutes and will occur during class time. If you decide not to participate, your teacher will provide you with an alternative activity.

Participating in this study means that your survey responses will be included in my research. Everyone participates in classroom learning, even if some students choose not to participate in the study.

The information you give will not have your name tied to it, so we won’t know what answers you give. Although we may be able to figure out who you are because of your answers, we won’t try to do so.

Survey results will be stored at UVA, only accessible by the researcher. Only the entire group's responses will be in my report; they will not be broken down to individual responses.

Participating in this study will bring you no harm. The case used in the study will be performed in conjunction with your teacher, who will be fully engaged in planning and execution.

If you participate in this study, there won't be any benefit to you. But, on the other hand, the study may help us understand how sports analytic cases may affect your STEM motivation.

Your participation in the study is completely voluntary. Therefore, your grades and school services will not be affected by your decision whether to participate in the study.

You have the right to withdraw yourself from the study at any time without penalty. However, because the surveys are anonymous, your submitted surveys cannot be withdrawn.

If you want to stop doing the study, close your browser and do not submit the survey. There is no penalty for stopping.

The data you provide in this study will be retained in a secure manner by the researcher for 2 months and then destroyed.

You won't receive any money if you do the study.

If you have questions about the study, contact:
Researcher's Name: Jeffrey Basoah
Department of Engineering Systems and Environment, 151 Engineer's Way
University of Virginia, Charlottesville, VA 22903.
Telephone: (434) 924-5395
Email: jkb2jf@virginia.edu

Faculty Advisor's: Dr. William Scherer
Department of Engineering Systems and Environment, 151 Engineer's Way
University of Virginia, Charlottesville, VA 22903.
Telephone: (434) 982-2069

To obtain more information about the study, ask questions about the research procedures, express concerns about your participation, or report illness, injury or other problems, please contact:
Tonya R. Moon, Ph.D.,
Chair, Institutional Review Board for the Social and Behavioral Sciences
One Morton Dr Suite 500
University of Virginia, P.O. Box 800392
Charlottesville, VA 22908-0392
Telephone: (434) 924-5999
Email: irbsbshelp@virginia.edu
Website: https://research.virginia.edu/irb-sbs
Website for Participants: https://research.virginia.edu/research-participants
UVA IRB-SBS # 4946

Agreement:
By clicking "Yes," I agree to participate in the research study described above and will proceed to the survey.

You may print or save a copy of this form for your records.

APPENDIX C

Demographic Portion of Survey

1. What is your sex?
    a. Male
    b. Female
2. What grade are you in?
    a. 9^{th}
    b. 10^{th}
    c. 11^{th}
    d. 12^{th}
3. Are you Hispanic or Latino/Latina?
    a. Yes
    b. No
4. If you are Hispanic or Latino/Latina, which one of the following are you?
    a. Mexican, Mexican American, Chicano
    b. Cuban
    c. Dominican
    d. Puerto Rican
    e. Central American (Guatemalan, Salvadoran, Nicaraguan, Costa Rican, Panamanian, Honduran)
    f. South American (Colombian, Argentinian, Peruvian, etc.)
5. Please select one or more of the following choices to best describe your race.
    a. White
    b. Black/African American
    c. Asian
    d. Native Hawaiian or Other Pacific Islander
    e. American Indian or Alaska Native
6. If you marked Asian in question _, which of the following are you?
    a. Chinese
    b. Filipino
    c. Japanese
    d. Korean
    e. Southeast Asian (Vietnamese, Laotian, Cambodian/Kampuchean, Thai, Burmese)
    f. South Asian (Asian Indian, Bangladeshi, Sri Lankan)
7. Is English your native language (the first language you learned to speak when you were a child)?
    a. Yes
    b. No
8. How far in school did your parents go? Indicate your mother's and father's highest level of education?
    a. Mother (or female guardian)
        i. Did not finish high school
        ii. Graduated from high school or equivalent (GED)
        iii. Graduated from high school and attended a two-year school (such as vocational or technical school, a junior college, or a community college), but did not complete a degree
        iv. Graduated from a two-year school (such as a vocational or technical school, junior college, or a community college)
        v. Graduated from high school and went to college, but did not complete a four-year degree
        vi. Graduated from college

        vii. Completed a Master’s degree or equivalent
        viii. Completed a Ph.D., M.D., or other advanced professional degree
        ix. Don’t Know
        x. Does Not Apply
    b. Father (or male guardian)
        i. Did not finish high school
        ii. Graduated from high school or equivalent (GED)
        iii. Graduated from high school and attended a two-year school (such as vocational or technical school, a junior college, or a community college), but did not complete a degree
        iv. Graduated from a two-year school (such as a vocational or technical school, junior college, or a community college)
        v. Graduated from high school and went to college, but did not complete a four-year degree
        vi. Graduated from college
        vii. Completed a Master’s degree or equivalent
        viii. Completed a Ph.D., M.D., or other advanced professional degree
        ix. Don’t Know
        x. Does Not Apply

9. How much do you like school?
    a. Not at all
    b. Somewhat
    c. A great deal
10. How important are good grades to you?
    a. Not important
    b. Somewhat important
    c. Important
    d. Very important
11. Do you plan to continue your education right after high school or at some time in the future?
    a. Yes, right after high school
    b. Yes, after staying out of school for one year
    c. Yes, after staying out of school for one year
    d. Yes, but I don’t. know when
    e. No, I don’t plan to continue my education after high school -> Skip to question __ on page __
    f. I don’t know if I will continue my education after high school -> Skip to question __ on page __
12. Which of the following do you plan to attend?
    a. Four-year college or university
    b. Two-year community college
    c. Vocational, technical or trade school

APPENDIX D

Pre – Survey (Intervention)

Enter your student identifier code. Your teacher should have given this to you before you began this survey. (Fill in blank)

In order to better understand what you think and feel about your STEM courses, please respond to each of the following statements.

1. I am motivated towards my studies (AE1)
2. I expect to do well in my class (AE2)
3. I try to make connections between what I learn from different parts of my classes. (AE3)
4. I put a lot of effort into the work I do. (AE4)
5. I use feedback on my work to help me improve what I do. (AE5)

6. I am able to propose a research question. (SE1)
7. I am able to design steps of research. (SE2)
8. I am able to conduct scientific research. (SE3)
9. I am able to arrange and represent findings of research. (SE4)
10. I am able to use technological product. (SE5)
11. I am able to define the problem to be solved. (SE6)
12. I am able to design solutions to the problems. (SE7)
13. I am able to test and compare different solutions. (SE8)
14. I am able to refine solutions. (SE9)
15. I am able to collect data. (SE10)
16. I am able to analyze data. (SE11)
17. I am able to represent data with graphs. (SE12)

18. I know I can learn the material in my STEM class. (EXP1)
19. I believe that I can be successful in my STEM class. (EXP2)
20. I am confident that I can understand the material in my STEM class. (EXP3)

21. I think my STEM class is important. (VAL1)
22. I value my STEM class. (VAL2)
23. I think my STEM class is useful. (VAL3)

24. My STEM classwork requires too much time. (COS1)
25. Because of other things that I do, I don't have time to put into my STEM class. (COS2)
26. I'm unable to put in the time needed to do well in my STEM class. (COS3
27. I have to give up too much to do well in my STEM class. (COS4)

28. Would you be willing to participate in a brief, follow-up interview? The interview will occur during BK time. (Yes/No)

APPENDIX E

Pre – Survey (Control)

Enter your student identifier code. Your teacher should have given this to you before you began this survey. (Fill in blank)

In order to better understand what you think and feel about your STEM courses, please respond to each of the following statements.

1. I am motivated towards my studies (AE1)
2. I expect to do well in my class (AE2)
3. I try to make connections between what I learn from different parts of my classes. (AE3)
4. I put a lot of effort into the work I do. (AE4)
5. I use feedback on my work to help me improve what I do. (AE5)

6. I am able to propose a research question. (SE1)
7. I am able to design steps of research. (SE2)
8. I am able to conduct scientific research. (SE3)
9. I am able to arrange and represent findings of research. (SE4)
10. I am able to use technological product. (SE5)
11. I am able to define the problem to be solved. (SE6)
12. I am able to design solutions to the problems. (SE7)
13. I am able to test and compare different solutions. (SE8)
14. I am able to refine solutions. (SE9)
15. I am able to collect data. (SE10)
16. I am able to analyze data. (SE11)
17. I am able to represent data with graphs. (SE12)

18. I know I can learn the material in my STEM class. (EXP1)
19. I believe that I can be successful in my STEM class. (EXP2)
20. I am confident that I can understand the material in my STEM class. (EXP3)

21. I think my STEM class is important. (VAL1)
22. I value my STEM class. (VAL2)
23. I think my STEM class is useful. (VAL3)

24. My STEM classwork requires too much time. (COS1)
25. Because of other things that I do, I don't have time to put into my STEM class. (COS2)
26. I'm unable to put in the time needed to do well in my STEM class. (COS3
27. I have to give up too much to do well in my STEM class. (COS4)

APPENDIX F

Hack-a-Shaq

Warm Up

Shaquille O'Neal, also known as Shaq, is best known for two things: being arguably the best big man in basketball history and his poor free throw shooting. Because of Shaq's poor free throw shooting, teams purposefully fouled him in order to close the score gap if they were trailing, forming the defensive strategy Hack-a-Shaq.

Shaq's career statistics are listed below. Examine his statistics to see if you, as the opposing team, would have used the Hack-a-Shaq strategy.

FGM	**FGA**	**FTM**	**FTA**
11390	19457	5935	11252

Probability of Shaq's making a field goal (worth 2 Points)		
Made field goals/ Attempted field goals	11390/ 19457	.585

Probability of Shaq making a free throw (worth 1 Point, two attempts)		
Made free throw/ Attempted free throw	5935/ 11252	.527

Expected Value of Shaq's making a field goal		
2 * probability of field goal	2 * .585	1.17

Expected Value of Shaq's making a free throw		
1 * probability of free throw + 1 * probability of free throw	1 *.527 + 1*.527	1.05

Activity Description

July 17th, 2021- Game 5 of the NBA Finals, the Milwaukee Bucks are playing the Phoenix Suns. Score is 117 Bucks, 119 Suns. The Suns have called a time out with 7.6 secs left on the clock and the Bucks will inbound the ball when the game resumes. The Bucks are in the bonus and Giannis Antetokounmpo for the Bucks has been on fire all night from the floor. Monty Williams, the Suns head coach doesn't want to give the bucks a chance to come down and tie the game. He is considering fouling one of the Bucks players before they can get a shot up and send to the line. He believes that if he sends the right player to the line they might miss a free throw, thus giving the game to the Suns if they can protect the ball. On the other hand, Monty also thinks that if he can win if he can force the Bucks into letting someone other than Giannis shoot, but who? He is concerned that the player who he leaves open for the shot might not only tie it up with a two-pointer, but possibly a three pointer as well.

Luckily, it is a TV timeout so Monty is able to turn to you, his trusted sports analyst and seek advice. He wants to know which player the team should target and what he should have them do, shoot the field goal or send them to the line.

Breakdown of the Problem

Describe the situation in your own terms. What problem are you trying to solve?

Who do you need to consider in this decision? Consider anyone who might care about the decision you make, also known as *stakeholders*.

What data or information might you need to help you with your decision?

How do you know you have given the best solution? (What are you going to use to showcase how fouling player A is better or worse than fouling player B?)

What are the limitations that you face when making your decision? (What do you have to consider when thinking of who to foul or leave open to shoot?)

What assumptions do you have to make about your decision?

Data Analysis

You have determined that the best way to determine the probability of a make or miss is to use the players free throw and shooting percentages from the floor. You have the season stats for each player that will be on the floor in the last seconds of the game. Calculate the field goal and free throw percentage for each player.

Players	**FGM**	**FGA**	**3PM**	**3PA**	**FTM**	**FTA**
Jrue Holiday	7.0	13.9	1.9	4.8	1.8	2.3
Khris Middleton	7.5	15.8	2.2	5.4	3.1	3.5
P.J. Tucker	0.9	2.3	0.7	1.7	0.2	0.3
Giannis Antetokounmpo	10.3	18.0	1.1	3.6	6.5	9.5
Brook Lopez	4.6	9.1	1.4	4.0	1.7	2.0

Example:

Probability of Jrue Holiday making a field goal (worth 2 Points)		
Made field goals/ Attempted field goals	7/ 13.9	.503

Probability of Jrue Holiday making a field goal (worth 3 Points)		
Made field goals/ Attempted field goals	1.9/ 4.8	.396

Probability of Jrue Holiday making a free throw (worth 1 Point, two attempts)		
Made free throw/ Attempted free throw	1.8/ 2.3	.78

Expected Value of Jrue Holiday making a field goal (2 pointer)		
2 * probability of field goal	2 * .503	1.01

Expected Value of Jrue Holiday making a field goal (3 pointer)		
3 * probability of field goal	3 * .396	1.19

Expected Value of Jrue Holiday making a free throw		
1 * probability of free throw + 1 * probability of free throw	1 *.78+ 1*.78	1.57

Develop a Strategy

Looking at your results, what are some observations? Anything standout to you, or results that are unexpected/expected?

Who are you going to recommend to foul or let shoot?

Why did you recommend that decision?

APPENDIX G

Control Group Activity

1. 150 raffle tickets are sold for $6.00 each. There are four grand prizes for $500 and five consolation prizes of $100 each that will be awarded. What are the possible outcomes along with their probability?

Outcome	x	Probability P(x)	

2. What is the expected value of the raffle ticket?

Test taking: Should you guess?

3. You are taking a test with 3 choices. If you guess incorrectly then you will lose .5 points, if you guess correctly then you will gain a point. What are the outcomes along with their probability?

Outcome	x	Probability	

4. What is the expected value of guessing on a question?

5. Investing: Which investment portfolio should you buy? Find the expected value for each of the three options.

A

Outcome	Probability
$20,000	.05
$30,000	.32
$50,000	.36
$75,000	.24
$100,000	.03

E(x)=_______

B

Outcome	Probability
$20,000	.15
$30,000	.25
$50,000	.14
$75,000	.23
$100,000	.23

E(x)=_______

C

Outcome	Probability
$20,000	.36
$30,000	.12
$50,000	.04
$75,000	.05
$100,000	.43

E(x)=_______

Find the expected value of winnings for each game.

1. Jennifer is playing a game at an amusement park. There is a 0.1 probability that she will score 10 points, a 0.2 probability that she will score 20 points, and a 0.7 probability that she will score 30 points. How many points can Jennifer expect to receive by playing the game?

2. Luanda played a game in which she could win 10 points with a probability of 0.2. There is a 0.8 probability that she will not win any points. How many points can Luanda expect to win?

3. Rudy is purchasing a toaster. Of the toasters in the store, 70% cost $10, 20% cost $20, and 10% cost $50. How much can Rudy expect to pay for a toaster?

4. Half of the players of a game win 100 points, and the other half win 200 points. How many points can Edie expect to win if she plays the game?

5. Matt wants to purchase a book at Jo's Bookshop. Of the books in the shop, 60% cost $10 and 40% cost $12. How much can Matt expect to pay for a book at Jo's Bookshop?

APPENDIX H

Focus Group Interview Questions

Opening Script

Thank you all for meeting with me today and agreeing to talk.

My name is Jeffrey Basoah and I am graduate student at UVA

Our conversation today will focus on your experience this past week with the sports-related activity.

Please know that anything you say during our time will be kept anonymous

Please speak clearly as your audio will be transcribed for ~~later~~ analysis

Throughout our time together please understand that I will continuously ask you to explain your responses in further detail so that I can accurately capture your experiences

1. Monday, I conducted a sports-related activity in your 6-period class with Mr. Henderson. What was your experience like doing the activity?
2. What did you like about the activity?
3. What did you dislike about the activity?
4. If you could change anything about the activity, what would it be?
5. How did you feel using the basketball teams to learn about probability?
    a. If the activity didn't use basketball teams would you have wanted to use another sport?
    b. If you had to choose a different topic than sports, what's a topic that you would have liked to use?
6. What, if anything, did you learn from the activity?
7. How did using sports impact your ability to problem solve?
    a. Did it make it easier? Or did it make it harder? Or was it in between?

APPENDIX I

Classroom Instructor Interview Questions

1. How was you experience teaching the activity?
2. Did you notice any students that were more or less engaged than usual?
3. Did you see any change in grade averages of any sorts?
4. What did you like about the activity?
5. What did you dislike about the activity?
6. Where there any students who outwardly expressed a dislike or advocated for the activity?

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