Experimental and Credentialing Capital: An Adaptable Framework for Facilitating Science Outreach for Underrepresented Youth

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***Abstract*— Increasing the numbers of black, latino and native youth in STEM careers is both an important way to reduce poverty in low income communities, and a contribution to the diversity of thought and experience that drives STEM research. But underrepresented youth are often alienated from STEM. Two new forms of social capital have been identified that can be combined to create a learning environment in which students and researchers can meet and explore an area of shared interest. Experimental capital refers to the intrinsic motivation that students can develop when they learn inquiry techniques for exploring topics that they feel ownership over. Credentialing capital denotes a shared interest and ability between all parties engaged in the experimental endeavor. These two forms of social capital form an adaptable framework for researchers to use to create effective outreach programs. In this case study sports biomechanics was utilized as the area of shared interest and understanding the slam dunk was used as experimental capital.**

I. Introduction

As the United States National Science Foundation continues to emphasize community outreach under its "broader impacts" criterion, there are added incentives for researchers to become involved in outreach activities. These outreach events traditionally focus on the specific branch of STEM (Science, Technology, Engineering and Mathematics) in which the researcher's expertise resides. The unspoken assumption is that communicating the details of one's scientific area will ignite similar passions in students. However, there is little evidence that this is an effective strategy for engaging students from populations that are underrepresented in the STEM fields. For example simply exposing girls to female scientists is not sufficient; they need connections to their own motivations.[1] Our current study introduces an alternative framework that we refer to as "experimental capital." Our approach begins by finding a non-science activity of common interest to both the scientist-educator and the youth participants. The scientist and the learners subsequently investigate this activity through a scientific lens, using the scientist's research expertise. Because the youths are engaged in an activity that they already have an intrinsic interest in, they are more comfortable while being guided through the activity by the scientist-educator. This allows learners to feel a sense of "ownership" over the activity, and because the scientist has now entered into the youth's world in ways that are authentic and respectful, this approach can dramatically change the appeal and effectiveness of STEM outreach.

In his study of education in France, Bourdieu introduced the concept of "cultural capital" to describe how the lack of access to upper class culture was used as a barrier to keep working class youth stuck in working class jobs.[2] Eglash and Bennett extend that concept by introducing "computational capital"—the knowledge of algorithms, iteration and other math or computing concepts embedded in cornrow hairstyles, native beadwork or other cultural heritage materials.[3] Their software allows users to "translate" between these "heritage algorithms" as they are known by the original artisans, and the same concepts as they are represented in the classroom. Their work shows statistically significant improvement when youth are learning math and computing through their own heritage materials, and using that in creative ways to make their own algorithm-based designs.

Following that trajectory, we introduce two new types of social capital for early student engagement in the STEM fields. "Experimental capital," like computational capital, is a resource that can be utilized to intrinsically motivate students to engage with material. But unlike the "heritage algorithms," which depend a student's sense of ownership over a heritage design practice, "experimental capital" depends on ownership over something to be investigated--knowledge that is not yet known.

Conducting STEM lessons in the context of practices such as sports, dance, cooking, music, or similar endeavors with a group of students who are enthusiasts mean they are intrinsically motivated to improve and understand their own performance. Once we establish that a STEM-based experimental method can improve that performance, we are intrinsically motivating STEM learning which is linked to enhanced learning outcomes.[4] However we caution that a teacher who is completely unfamiliar with the practice may come off as patronizing or duplicitous. This brings us to the concept of "credentialing capital." Since it is common to offer "credentials" when entering a restricted zone, we refer to this sense of mutual membership or "in group identity" as "credentialing capital."[5] We hypothesize that in the case of STEM lessons based on experimental capital, those in which that sense of ownership is mutually shared between students and teacher--in which both have "credentialing capital"--will be most effective. This does not mean they are all experts in this area of shared interest; merely that they have some sense of "cultural ownership" -- amateurs, fans, or perhaps simply authentic curiosity over that domain will likely do, as long as generates sufficient intrinsic motivation on the part of

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learners and avoids the impression of a patronizing outsider on the part of teachers.

Our case study examines a case in which credentialing is clearly established in the Area of Shared Interest (ASI) between scientist and the K-12 audience. In this case study, we examine these experiments in the context of sports, an activity that students often feel a sense of ownership, but for which particular physical phenomena may not be known.

II. Methods

We have previously reported on utilizing students interest and understanding of basketball to introduce the scientific method in an engaging manner using an interactive program called "The Science of the Slam". [6] In this study we look to expand on those themes and invite students to become the partners in the generation of these outreach programs.

In the summer of 2014 we experimented with the intersection of these two forms of social capital--experimental capital and credentialing capital--with 50 inner city high school students during a 5-week program called "The Science of Athletic Performance." The program was performed as part of a larger summer work employment program called "Summer Matters Academy". We partnered with 4th Family Incorporated, a local non-profit with close community ties, to help recruit students. By utilizing the students' intrinsic interest in sports performance as experimental capital, STEM topics were explored in depth. Sports served as an ASI within which to use STEM topics; students were engaged with questions that naturally arose in their own pursuits. Six graduate students in biomedical engineering were employed as instructors; they were "credentialed" by a passion for sports. This created a meeting place in the gap between the STEM world and the world these students inhabit. The program consisted of two hour-long meetings a week, on Mondays and Wednesdays. During the first hour, a new sports science experiment was performed with the help of a guest speaker who was a high level athlete in a given sport. Examples include Olympians, Division I athletes and semi-professional athletes. Each student group attempted to design an experiment to measure the athletic ability of the elite athlete for comparison to their own performance. Each group utilized biomechanics lab equipment consisting of Electromyography recorders (EMG), light sensors to act as photogates, and force plates to measure ground reaction force. All equipment was purchased from Vernier Software and Technology (OR, USA).

During the second hour, student groups worked on developing their own project that focused on investigating an athlete of their choice. The graduate mentor for each group assisted with the investigation; however, students selected the topic and executed the project. An example of a project is found in Fig. 1.

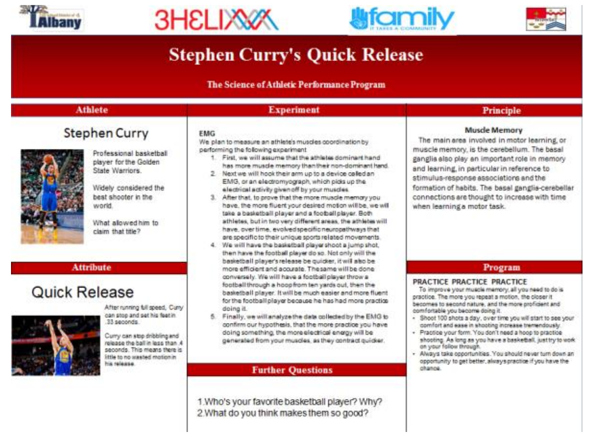

Figure 1. Each group completed a poster that summarized the work that they performed over the summer program. Each group chose an athlete and developed a training program that was focused on improving themselves based on the percieved strength of the chosen athlete.

The capstone for the program occurred at the Rensselaer campus where the student groups presented their work in a poster session to a professional panel that consisted of sports trainers, biomedical engineering professors, and sports health professionals. These "sports science" professionals gave positive feedback to the students as a way to validate the students' newly acquired credentials in the STEM fields.

The students who participated in the summer program were given the opportunity to continue involvement in the program during the school year as an after school program hosted at the local high school. The afterschool program focused on utilizing analysis techniques and presentation skills introduced over the summer to create sport science modules to be presented at basketball clinics and other community events.

III. Results

The summer program served 50 students who produced eight posters for presentation at the Rensselaer Polytechnic Institute. Posters were later utilized for presentations to younger students around the community as shown in Fig. 2.

Figure 2. Students who participated in the summer program were given the oppourtunity to present their work to groups of younger students.

The cohort consisted primarily of African American youths (85%); the rest of the youths were Caucasian (15%).

The majority of participants were male (75%), although there was female interest as well (25%). Post-program interviews with the students about "The Science of Athletic Performance" were mostly positive. Most students praised the concentration of the program on the sports subject matter. When asked about his favorite summer program, one student said: "I like the STEM program because it is about sports, and I am an athletic person." Another student stated: "I liked STEM, because I got to learn about bioengineering." This particular pair of responses is interesting because they may indicate that the program successfully reached students with entirely different motivations for participation who nevertheless share overlapping credentials.

There was some criticism that there was not enough material for people who were uninterested in sports. One female participant stated that she "wished there was more for the girls" in the group. This brings into focus one of the potential issues with the experimental and credentialing capital approach to outreach: if a student does not share the ASI, the material will not be as compelling. To address this limitation, it is necessary to adapt this framework to other ASIs with other investigators with the proper credentialing capital.

This framework has been adapted to reach other audiences. Recently, a female biomedical engineering graduate student at RPI who is a competitive ballroom dancer has created an outreach module that is focused on analyzing the biomechanics of dance. She is partnering with a local ball room dance youth program and will be hosting a clinic on campus that will include a "Science of Dance" segment. Additionally, another graduate student is working on a video game design program in which students are recruited due to their interest in making basketball video games. After engagement in the ASI, experimental capital will be utilized to have the students create a video game. In this manner, inclusive outreach can be achieved by recruiting new scientists with different preferred ASIs while maintaining authentic, compelling programming.

The after-school program had a retention rate of approximately 20% from the summer program, most of whom were basketball players at the local high school. As a result, the program shifted its focus to exclusively basketball topics, which subsequently reduced participation of non-basketball player students. We entered an official partnership with the men's basketball program at the high school, which enabled us to entirely focus on basketball as the ASI. The students from the summer program took leadership positions in showing other students how to use the equipment. We created a student-driven version of the "Science of the Slam" where students were charged with running the equipment, organizing the participants, and analyzing data. [6] Our students successfully presented the "Science of the Slam" on three separate occasions to groups of younger students, including at basketball clinics and at their school.

Figure 3. Students were trained to use the biomechanics equipment and how to run the program. The program was brought to basketball clinics and presented as a method to improve performance. The two seated students are collecting data from a set of force plates that measure ground reaction force while the student on the left is recording participant results. In this manner students are credientialled in STEM topics among their peers.

The program culminated in an hour-long event as part of the Youth Summit at the State Capital of New York. An audience of over 100 participated in an on-stage dunk contest that involved correlating dunking ability with the ground reaction force generated to predict the winner of the contest.

Figure 4. Student volunteers assisted in collecting data and organinizing the "Science of the Slam" at the New York State Capital. They ran an on-stage dunk contest on a seven foot basketball hoop in which the force generation ability of each contestant from the crowd was measured using force plates and correlated to dunking ability.

After positive reviews from our hosts at the high school, the summer program is being repeated and expanded to three programs, "The Science of Athletic Performance," "The Engineering of Athletic Performance," and "Seeing and Coding the World Through Game Development."

IV. Discussion

Sports are frequently used as illustrative examples in STEM education; for example, most physics textbooks will contain an illustration of parabolic trajectory as a ball in flight. Unfortunately, this can be perceived as pandering or patronizing to youths who are often told something as generic as: "This equation shows why you basketball players should be interested in physics." Here, the connection between sports and physics is superficial at best. However, these are examples in which a sports activity is abstracted; the same equation would work just as well for tossing rocks or launching satellites. Additionally, we note that the connection is not simply offered as "STEM connections for the sake of

STEM." Scientist-educators and students utilize analytical STEM techniques to optimize sports performance. In this manner, the focus of the program is on a shared interest in sports, and not on STEM topics. Sports take the center stage while STEM is wielded as a tool students can use to examine and improve their athletic performance. This approach allows the program to attract students who are interested in sports, but are not initially credentialed with an interest in the STEM fields. Once the students complete the program, they become credentialed in the STEM fields by presenting their work to other students. In other words, credentialing is a two-way street and may serve as a way to expand the STEM career pipeline to students who are not predisposed to an interest in STEM.

At the heart of the STEM fields there is an underlying methodology that allows STEM practitioners to collect, analyze and draw conclusions from empirical data. Different fields have different methods and forms of data, but the overall goal remains the collection and analysis of reliable data. In the case of practicing scientists, we have taken these skills and applied to a narrow band of topics that are only accessible to our similarly skilled peers. Our skills in data collection and analysis are easily applicable to other topics and fields provided a reliable source of data. With the rise of cheap, accessible electronics and processing power, this type of accurate data can be collected for almost any activity. Scientists have many interests and hobbies outside of their work in the STEM fields. These hobbies can serve as an ASI between practicing scientists and a similarly credentialed K-12 audience. The scientist-educator can effectively incorporate STEM topics in their chosen ASI in a compelling, relatable way.

This allows the outreach paradigm to be flipped from a STEM-centric model, in which scientists are the generators of knowledge and the K-12 audience is the consumer, to a model in which scientists and the K-12 audiences meet in an ASI to generate knowledge that both parties find compelling. The use of the ASI creates a two-way flow of information in which all participants have a voice. This prompts the students to take an active, hands-on role in the learning and it frees the scientist from having to come up with ways to sugarcoat their work for mass consumption. This approach is especially attractive for early career scientists who lack teaching experience, but are able to find common ground with students through ASI.

V. Conclusion

We have proposed a new method of engaging underrepresented groups by tapping into new forms of capital. By engaging students with outreach that is centered on shared interests where science is not the focus, but rather a tool for understanding, more effective programming for urban STEM education can be created. Using the intersection of experimental and credentialing capital, scientists can create effective outreach programs that engage diverse students without a pre-existing interest in STEM.

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