The power of out of school engagements: Developing high school students' identities as forensic scientists.

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Abstract: In response to job markets, organizations are seeking to design educational opportunities that may influence students to pursue careers in forensic science. More research is needed that explores whether out of school engagements develop students' identities as forensic scientists. This article examines how high school students described their evolving identities as forensic scientists before and after participating in an out of school engagement. Three key factors shaped the out of school engagement described in this study: a) student social interaction with peers, b) student directed decision making, and c) student inquiry facilitated by experts. The out of school engagement also provided students with opportunities to experiment with ways of communicating science. Pre and post engagement survey results suggest that the out of school engagement appeared to change some students' perceptions as to whether they would consider themselves forensic scientists. Based on the results of the study, it is suggested that out of school engagements provide valuable opportunities to help high school students develop their identities as forensic scientists. By examining the design of the out of school engagement described in this article, science educators, administrators, parents, and other stakeholders may develop ideas as to how to develop students' identities as forensic scientists.

Keywords: forensic science, high school, science identity, diversity

Introduction

As educators continue to highlight the importance of increasing high school students' engagement with science (1), recent research has highlighted the significance of supporting high school students within specific scientific disciplines (2). The demand for forensic scientists is expected to grow much faster than for any other occupation (3), inspiring educators to design programs and curriculum to prepare students to meet the upcoming labor demand. Programs located outside of traditional high school classroom settings have positively influenced students' interest in STEM (4). For example, science camps have been found to support students' positive attitudes about both science in general and more specifically the application of forensic science (5). While partnerships with local universities have supported high school students' development of disciplinary understandings in biology (6) and health sciences (7), more research is needed on the impact of out of school engagement activities for high school students that focus on the field of forensic science. Enrichment engagements located outside of traditional classrooms may increase students' interest in STEM by helping students develop identities specifically in forensic science.

More research is needed that explores not only how out of school engagements influence students' understandings of the content of forensic science but also how students develop identities as forensic scientists. In addition, research is needed that identifies specific academic and social elements that influence interest in STEM among students from diverse populations (4). In order to meet these needs, the researchers developed an out of school engagement located at a university. This article focuses on two research questions: What are high school students' beliefs about their scientific identities before and after participating in an out of school engagement? How may an out of school engagement be constructed to support students' evolving identities as forensic scientists? The answers to these questions may provide support for educators, families, and stakeholders who wish to inspire high school students to investigate forensic science. When educators, families, and stakeholders learn about strategies for increasing science students' aspirations through participation in out of school engagements, students will likely advance socially and academically (8).

Out of school science engagements often share the characteristics of being voluntary, not attached to formal curriculum, and varying widely in scope (4). These characteristics were found within the engagement that the high school students participated in during the study described in this article. The engagements were structured, since they were organized around their own curriculum (9). While many curriculum studies in forensic science unite theoretical and contextual knowledge with hands on laboratory experiences (10), the experiences described in this article are viewed through the lens of identity building. We describe how a university professor, a university teaching assistant, and high school students interacted during a day of out of school engagement taking place at a university. Specifically, this article describes an approach to pedagogy that focuses on identity building within the field of forensic science.

Science identities are formed through social practice (11). Forensic science identities may develop as students engage in social practices that they come to associate with being a forensic scientist. While forensic science requires strong powers of observation, engagement in logical reasoning, and the ability to engage in evidence-based argumentation (12), there are also key rituals and exchanges that inform forensic science identities. Social cultural contexts help construct science identities (13). The science identities of women of color may be informed by social perceptions of competence, performance, and recognition (14). This indicates that identity may be developed as a reaction to engagements experienced with others. Carlone and Johnson (14) note, "A science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person." (p. 1192) Within the study described in this article, the university professor, university teaching assistant, and students themselves all had the power to influence how individuals came to situate themselves within the field of forensic science. This article provides insights into what occurred during exchanges within the out of school engagement and how other parties may engage high school students in identity building.

Methods

Participants in the study included 23 high school students, one university faculty member, one university teaching assistant, and two high school teacher chaperones. The high school students who attended the out of school engagement at the urban Mid-Atlantic university were selected from two high schools containing racially diverse populations. **TABLE 1** displays demographic information for both high schools. The university that was the location for the out of school engagement is a large institution serving a minority-majority undergraduate population. In addition, it is important to note the demographic information of the adults participating in the engagement, since they too help to shape students' identities. The university professor is a white female who identifies as a member of an underrepresented population as defined by the National Institute of Health (15), and the teaching assistant is a white female who identifies as a member of the LGBTQ+ community. Since the students were transported by bus to the university campus to participate in the out of school engagement, two high school teachers were required to act as chaperones. Both of the high school teacher chaperones identify as black females.

TABLE 1 *Demographics of high school participants.*

	African American	**Hispanic**	**Asian**	**White**	**Other**
High School 1	53.68%	33.50%	7.14%	3.00%	2.68%
High School 2	85.43%	10.80%	1.62%	.85%	1.30%

Multiple selection criteria were used to determine the high school participants. Invitations to participate in an out of school engagement were offered to students from two different high schools. Participants/guardians signed permission slips allowing the students to participate in an out of school experience related to forensic science. The public-school high school teachers selected participants based on the order of returned permission slips. Participant selection criteria was as follows: attended at least one of two selected high schools; self-selected to sign up for out of school learning engagement focusing on forensic science; turned in a written parent/guardian permission; availability based on the order of returning permission slips; granted both self-consent and parent/guardian consent to participate in study.

Data collection occurred before, during, and after the out of school engagement. Three sources of data were collected. First, students responded in writing to a survey given in advance of the out of school engagement, prior to arriving at the university campus. Copies of this survey can be found in **Appendix A**. Second, students responded in writing to a survey given after of the out of school engagement. The questions on the pre and post survey were the same. The surveys were anonymous to encourage honest responses; however, given the anonymous nature of the survey we were not able to gather information about students' race, ethnicity, or language background. We were also not able to examine individual student's changes in perception but could look at changes in perceptions across the entire data pool. Third, students were observed as they produced written responses while participating in the out of school science engagement. These written responses were collected on the observation sheets. **Appendix B** contains a copy of the observation sheet.

Elements of Out of School Engagement

In order to encourage the development of students' identities as forensic scientists, the out of school engagement centered on three elements: a) student social interaction among peers, b) student directed decision making, and c) student inquiry facilitated by experts. The following discussion illustrates how each of these elements was implemented in order to encourage the development of students' identities as forensic scientists.

Student Social Interaction Among Peers

Forensic Science is centered around solving mysteries. Out of school engagements that focus on forensic science offer the opportunity for students to make individual contributions towards the achievement of a greater common goal (solving a mystery). As the university professor and university teaching assistant planned how to support students as they developed as forensic scientists, they set out to design an environment where students could engage in the rituals and routines that are common among forensic scientists. Sometimes the routines of forensic scientists involve collaboration with others. Within the field of forensic science, multiple collaborators often contribute different data sources that must be triangulated. Within the out of school engagement, high school students were given the opportunity to collaborate with their peers to achieve a common goal.

Within the out of school engagement, students were presented with two scenarios (see **Appendix C**). These scenarios presented students with realistic contexts that may be encountered within the work of forensic scientists. Students were then encouraged to both collaborate with their peers and use their writing to make sense of the data. Appendix B includes a copy of the reflection sheet distributed to each student. The reflection sheet called, "Who committed the crime?", guided students to compare and contrast data collected at the crime scene, garage of suspect one, and the car of suspect two. Students were encouraged to gather data and analyze it in self-formed groups of three or four. By revolving these interactions around collaboration, the students were engaging in a key routine inherent within forensic science.

Stations were set up in the room including stereo and compound light microscopes, a ballistics scope, an alternate light source, and the Kastle-Meyer serology test. In addition, STR DNA data was displayed on computer screens along the wall. This data included electropherograms for the suspect's DNA and the DNA that was found at the crime scene. All equipment was obtained from local chemical suppliers and vendors. The stereoscope (model EZ4) and compound light microscope (model DM500) and ballistics scope were obtained from Leica. An alternate light source (model MCS 400) was purchased from Spex Forensics, and the Kastle-Meyer serology test was purchased from Evident. Short tandem repeat (STR) DNA electropherograms were student data generated in the university's Forensic Science program using a commercial kit and a capillary electrophoresis instrument (model ABI 3500). As students worked at different tables, they were encouraged to use tools to gather evidence that would solve the mystery.

Students were given the opportunity to learn how to use several tools that provided different sets of data. Through peer collaboration, students could analyze the usefulness of each piece of newly gathered information and its impact on creating an answer to the mystery. The university faculty member and university teaching assistant provided tools that students could use to support critical thinking and identification as a forensic scientist. The adults modeled analyses from different units of the forensic lab including firearms/toolmarks, trace evidence, questioned documents, and biology (including DNA and serology). Students were also given information about the use of and function of following tools: stereomicroscopy, compound light microscopy, ballistic scope, alternate light source (ALS), serology – presumptive blood test: the Kastle-Meyer test. Students could then choose to use information provided by these tools to make conclusions about the mystery.

Student Directed Decision Making

After gathering serval sources of data, and comparing and contrasting the data, students were encouraged to analyze the data to form a conclusion. The bottom of the "Who committed the crime? reflection sheet asked not only, "Who committed the crime?" but also "How do you know who committed the crime?" Since students were encouraged to use data to support their findings, the decision-making process was student directed. Making evidence-based statements is an additional ritual and routine inherent within forensic science. By allowing students to make decisions based on their own analysis of the data, the out of school engagement encouraged students to develop identities as forensic scientists.

Student Inquiry Facilitated by Experts

As students attempted to engage with peers and make student directed decisions, the experts (the university professor and university teaching assistant) were able to support student inquiry as well. Primarily, the experts attempted to both inspire students by connecting forensic science to students' everyday lives and to present students with specific tools that can be used in forensic science. At the start of the engagement, the university faculty member attempted to motivate the students by disclosing concepts from the field of forensic science that connected to students' real lives. The university teaching assistant attempted to develop students' interest by making connections between DNA and students' personal histories. She stated, "About 99.7% of our DNA is the same and only 0.3% differs from one another. Half of your DNA is inherited from your biological mother and half from your biological father." This example demonstrates one way the experts attempted to draw students' interest to real life purposes for using forensic tools.

By directly using tools to solve mysteries, students experienced some of the transactions that occur among individuals who engage in careers in forensic science. Students were also asked by the adults to wear some of the personal protective equipment worn by forensic scientists. Asking students to use goggles while performing the presumptive blood test allowed students to further experience the rituals and routines of forensic scientists. Experts can develop students' identities as forensic scientists by helping them experience the numerous tools, rituals, and routines of the field.

Results

The out of school engagement appeared to change students' perceptions as to whether they would consider themselves forensic scientists. **TABLE 2** shows an increase from 3.85% to 30.43% in students who labeled themselves specifically as forensic scientists after participating in the out of school engagements. In addition, **TABLE 3** indicates that after the out of school engagement there was an increase from 19.24% to 34.78% in students who saw themselves within the general categories of scientists, mathematicians, or forensic science.

TABLE 2 *Students evolving identities as forensic scientists.*

	Did identify as a forensic scientist
Pre-engagement	3.85%
Post engagement	30.43%

TABLE 3 *Students evolving identities in the general fields of forensic science/science/mathematics.*

	Did identify as a forensic scientist/ scientist/ mathematician	**Not sure**	**Did not identify as a forensic scientist/ scientist/ mathematician**
Pre-engagement	19.24%	0	80.76%
Post engagement	34.78%	13.05%	52.17%

TABLE 4 provides examples of survey responses that demonstrate why some students may or may not consider themselves to be forensic scientists after the out of school engagement. A portion of students consider themselves to be forensic scientists after the out of school engagement because they were able to successful solve the crime presented or because they experienced the process. In contrast, **TABLE 4** also presents examples from the data that provides context as to why students may not have identified as forensic scientists after the out of school engagements. Specifically, students spoke of identity markers established by outside parties. Some high school students referenced the lack of a degree or certifications as the reason why they did not identify as a forensic scientist. Some also began to understand the depth of the field of forensic science, causing them to hesitate to label themselves forensic scientists. For example, one student survey indicated, "I am not a forensic scientist because there is so much more to learn." In this case, it is unknown if the student increased their interest in forensic science while also developing knowledge about the field that prevented them from assigning themselves the label of forensic scientist.

TABLE 4 *Examples of students' reasoning for identifying or not identifying as forensic scientists.*

	Did not identify as a forensic scientist	**Did identify as a forensic scientist**
Pre-engagement	"I am not a forensic scientist because I don't fit the boxes that require you to be a forensic scientist"	"I think so because I have been given knowledge about forensic science."
Post engagement	"No. I don't have a degree." "No because I got to learn in my experience and I'm not certified.	"I am a forensic scientist because I have solved the crime." "Yes because I know the process of forensic science."

TABLE 5 shows that students indicated on their surveys that the out of school engagement made them think about science/ specific science/or math in their everyday lives. Many who referenced the influence on their everyday lives also indicated that STEM was included in what they wanted to do when they grew up.

TABLE 5 *Analysis of students' responses to inquiries about influence of out of school experience.*

Informal science learning experience influenced students' everyday life	**STEM was referenced when students discussed what they want to do when they grow up.**	**Students referenced BOTH influence of informal science learning experience on students' everyday life AND referenced STEM when discussing what they want to do when they grow up.**
65.22%	80%	52.17%

TABLE 6 *Analysis of one student's response to the "Who committed the crime? reflection sheet.*

Example of student's written response	**Critical thinking used in forensic science**	**Phrases used by student in communication of ideas within forensic science**
When comparing the note ink of suspect 2 and the evidence, they glowed the same. When looking at bullet casing, you can see that evidence and sample 2 had the same manufacturing model and the holes punched. When looking at the fibers, suspect 2 and evidence had the same color and curl pattern. All of this points to suspect 2 matching up to be the murder."	Compare and contrast data Triangulation of conclusions from multiple sources of data Use of multiple sources of evidence to support a conclusion	"When comparing…… … "…matches up…. "When looking at…." "All of this points to…."

Students' written responses to the observation sheet displayed in **Appendix B** demonstrate how they used language during the out of school engagement focusing on forensic science. While every student group solved the murder during the out of school engagement, the students' ability to communicate their ideas provided strong evidence of their evolving identities as forensic scientists. **TABLE 6** presents an example of a student's response to the "Who committed the crime?" refection sheet. The student's responses in Table 6 displays elements of the numerous types of critical thinking used in forensic science. The writing sample also shows the language choices that the student made while communicating their conclusions. This demonstrates how this student views communication as a forensic scientist at this point in time. Future studies may consider how students' written language choices change over time as they participate in out of school engagements focusing on forensic science.

Discussion and Conclusion

Internationally, reduced rates of secondary level students studying science have become a concern (16, 17). Educators, family members, and stakeholders are seeking ways to address the diminishing number of individuals who study science. This article demonstrates that out of school engagements have the potential to influence students' evolving identities as forensic scientists. As described in this article, the out of school engagement contained three components: a) student social interaction with peers, b) student directed decision making, and c) student inquiry facilitated by experts. The study described in this article suggests that when high students are supported during out of school engagements that involve these elements, some students may develop identities as forensic scientists. In addition, when students are given opportunities to communicate their thinking in writing during out of school engagements, they may begin to formulate identities as forensic scientists.

Given the increase in students who identified as scientists, mathematicians or forensic scientists after participating in the out of school engagement, the experience had a positive influence on many students' developing STEM identities. Growth is demonstrated when comparing the statements of some of the students before experiencing the out of school engagement to the statements made by students after the out of school experience. For example, before the informal science learning experiences one student indicated, "I am not a forensic scientist because I don't fit the boxes that require you to be a forensic scientist." This response highlights the societal forces that may shape individuals' identities as forensic scientists before they participate in out of school engagements. After participating in out of school engagements, any student who indicated that they were not currently a forensic scientist pointed to reasons that indicated lack of a degree or lack of education. None of the students wrote statements suggesting that outside forces such as race or gender shaped their potential to be a forensic scientist. It is possible that students still held these ideas, but the writing samples did not reflect this perspective.

It is important to note that the identities of the adults who participated in the study may have influenced evolving ideas about communication in forensic science. Within the study, high school students were able to engage with experts in forensic science who either identified as a member of the LGBTQ+ community or who were a white female from an underrepresented population. These experts drew on their own complex social cultural contexts to model language for the students. In addition, the fact that students, members of underrepresented populations, could watch their classmates engaging in forensic science may have influenced students' ideas surrounding how forensic science can be communicated.

Supportive out of school engagements should provide students with opportunities to experiment with ways of communicating science. In order to develop identities as forensic scientists, students need to navigate new language patterns that synthesize the ways that language can be used in the field of forensic science. Out of school engagements need to provide students with opportunities to both redefine language for themselves and experience new ways of using language as displayed by some experts. As students from underrepresented populations enter into the field of forensic science, they will bring with them new ideas about how to use language. Students must learn how to communicate with different parties such as other forensic scientists, police, judges, and lawyers. Each group evolves in its ways of negotiating language. By communicating with both peers and forensic science experts in out of school engagements, students can begin to experiment with how to negotiate language in different contexts.

There are two elements that must be considered when reflecting on the findings of the study. First, it is unknown if students were concurrently participating in other unstructured out of school activities centering on forensic science. Examples of these types of activities may include watching forensic science centered television shows or listening to forensic centered pod casts. It is suggested that future research examine how students' participation in these unstructured out of school forensic science engagement may influence students' identities as forensic scientists. Second, it is unknown if supporting the students to develop identities as forensic scientists will increase their aspirations to pursue careers in forensic science. Studies have suggested the connections between students' identities as scientists and their intentions in pursuing careers in science (18, 19).

As this article demonstrated, before entering into an out of school engagement in forensic science, students formulated ideas about who was or was not a forensic scientist. Out of school engagements have the potential to allow students to evolve in their ideas as to what an individual should look like or talk like as they engage in forensic science. Engagements that are facilitated by experts from underrepresented populations may influence students' evolving identities as forensic scientists. Out of school engagements also have the potential to allow students to experiment with how to use language to communicate ideas about forensic science. Chen et al (2) suggest that each student develops an identity in science when they are recognized by both themselves and others as a science person. Out of school engagements that are facilitated by experts from underrepresented populations may influence students' evolving identities as forensic scientists.

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Appendix A. Reflection survey

1. Describe what you think (name of specific type of science or math) is?
2. How would you describe to someone else what (name of specific type of science or math) is?
3. Did any activity from today make you think about (name of specific type of science or math) in your everyday life?
4. Did anything that you have read make you think about (name of specific type of science or math) in your everyday life?
5. Are you a (name of specific type of science or math) scientist/mathematician now? Why or why not?
6. What do you want to do for work when you grow up?

Appendix B: Who committed the crime?

1.What did you notice about the evidence from the crime scene?	2. What did you notice about items found in suspect one's garage?	3.What did you notice about items found in suspect two's car?

Compare column 1 to column 2. Next compare column 1 to column 3. Who committed the crime? Use your answers from the chart above to explain how you know who committed the crime. Write your answer below.

Appendix C. Mock Crime Scene Exercise

Scenario:

Yesterday evening the suspect broke into the victim's home. The victim's back window was found broken, indicating forced entry had occurred. Suspected blood was found on the windowsill. The victim was found with a gunshot wound to the head and bound at the wrist and ankles with duct tape. Fibers were found on the tape and a cartridge casing was found. A note was also found at the scene.

Suspect 1: Suspect one is the victim's neighbor. The victim has previously reported him multiple times for sneaking around her house and looking into her windows. Duct tape, a handgun, gardening gloves with suspected blood on them, and a red pen were found in the suspect's garage.

Suspect 2: Suspect one had reported seeing a mysterious car parked down the street from the victims house the night of the incident. A car matching suspect one's description was found two miles from the victim's house. A torn t-shirt with suspected blood on it, a handgun, duct tape, and a red pen were found in the vehicle belonging to suspect two.

A swab of the suspected blood found on the victim's windowsill was taken and a DNA profile was generated to compare to the DNA profile of both suspects.

Assignment:

Your job as the forensic scientist is to analyze the evidence that was recovered from the crime scene and compare it to the evidence found in suspect one's garage and suspect two's car to determine who committed the crime.

Instructor Notes: Fake blood and unloaded cartridge casings were used in this activity.