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Non-Science Major Undergraduate Students' High School Science Experiences: An Exploratory Case Study

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Abstract

Previous studies reported relatively low correlation coefficients between students' high school science experiences and their science identities. This needs more exploratory studies to investigate the reasons for these low correlation coefficients. This article presents the high school science experiences of three non-science major undergraduate students and the influence from their experiences, in their perspective, on their choice of a non-science major in college. Three female Hispanic non-science major undergraduate students were interviewed about their high school science experiences. Data were analyzed to answer the research question: From three female Hispanic students' perspectives, what are some factors from high school science experiences that influenced students' choice of non-science majors in college studies, particularly some specific factors related to their Hispanic cultural backgrounds and gender role. The most mentioned influential factor among three participants was didactic teaching styles of their high school science teachers. Another important finding was low performance/self-efficacy in math may predict students' low interest/persistence in science but high performance/self-efficacy in math does not necessarily predict students' high interest/persistence in science.

Keywords

Choice of Major, Female, Hispanic, Exploratory Case Study

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Previous studies reported relatively low correlation coefficients between students' high school science experiences and their science identities. This needs more exploratory studies to investigate the reasons for these low correlation coefficients. This article presents the high school science experiences of three non-science major undergraduate students and the influence from their experiences, in their perspective, on their choice of a non-science major in college. Three female Hispanic non-science major undergraduate students were interviewed about their high school science experiences. Data were analyzed to answer the research question: From three female Hispanic students' perspectives, what are some factors from high school science experiences that influenced students' choice of non-science majors in college studies, particularly some specific factors related to their Hispanic cultural backgrounds and gender role. The most mentioned influential factor among three participants was didactic teaching styles of their high school science teachers. Another important finding was low performance/self-efficacy in math may predict students' low interest/persistence in science but high performance/self-efficacy in math does not necessarily predict students' high interest/persistence in science. *Keywords: Choice of Major, Female, Hispanic, Exploratory Case Study*

The workforce in the field of science, technology, engineering, and mathematics (STEM) has been in great need in the United States for years (Augustine, 2005; National Science Board, 2010). Over one third of doctorates working in the STEM fields in the U.S. are born abroad (Atkinson & Mayo, 2011). One of the reasons for this fraction might be that lower percentage of students in the U.S. earned an associate or a bachelor's degree in science, when compared to their counterparts in other countries such as China and German (National Science Board, 2014b). Moreover, certain minorities, such as Black and Hispanic, and female students are still underrepresented in science programs and science careers (National Science Foundation & National Center for Science and Engineering Statistics, 2015). In order to provide the potential solution to this supply-demand issue, researchers need to investigate reasons why people in the U.S., especially of certain race/ethnicity/gender groups, pursue careers outside of STEM fields.

One of the research projects that have been conducted was Persistence Research in Science and Engineering (PRiSE). The PRiSE project was conducted with a nationally representative sample of undergraduate students who were enrolled in introductory English classes in the fall of 2007 throughout the United States. The PRiSE project examined the relationship between students' high school science experiences and their persistence in science. One analysis of the PRiSE data related factors from students' high school biology experiences and career outcome expectations with their biology identities and the other discussed students' high school physics experiences and career outcome expectations with their physics identities. In the research analysis of the PRiSE data about the relationship of high school physics experiences and career outcome expectations with students' physics identities, factors from high school physics experiences, along with career outcome expectations can explain 16% of students' physics identities (Hazari, Sonnert, Sadler, & Shanahan, 2010). The further quantitative analysis results from the PRiSE data indicated that there was a correlation of some factors from students' high school biology experiences and career outcome expectations with their biology identities; however, those factors can only explain 13% of their biology identities (Li, Hazari, Sonnert, & Sadler, 2014). Such relatively low correlation coefficients encouraged the research interest in exploring more factors from students' high school science experiences that may influence their science identities and science learning. The findings of several studies have suggested that science identity has an influence on students' science persistence (Aschbacher, Li, & Roth, 2010; Basu, 2008; Brickhouse, Lowery, & Schultz, 2000; Carlone & Johnson, 2007; Cleaves, 2005; Gilmartin, Denson, Li, Bryant, & Aschbacher, 2007; Shanahan, 2009). Therefore, we focused on the influence of high school science experiences on students' persistence in science. Specifically in this study, high school science experiences that influenced the research participants' choices to pursue non-science college majors was investigated.

The purpose of this study was to explore the relationship between high school science experiences and choice of non-science majors for college studies. Our research question was: From the perspective of three Hispanic female students, what factors from their high school science experiences influenced their choice of non-science college majors, particularly those specific factors related to their Hispanic cultural background and gender role.

Because of the primary researcher's role as a Ph.D. candidate and researcher in science education, he focused on improving science education in high school and promoting high school students' persistence in science career when conducing this study. The aim of this study was to inform high school science teachers and university science faculty, as well as science education faculty, of the factors that influence students' choices of non-science majors in college. With this information, the following could take place: High school science teachers could adjust their teaching strategies accordingly to better address students' needs and help students stay motivated; University science faculty could understand what factors are key, in order to stabilize the pipeline from students with science majors to scientists; Science educators might take the findings into consideration and reform their curriculum for pre-service science teachers.

The global significance of this local study lies in the fact that the article will be one of the few qualitative studies investigating high school science experiences as factors of subsequent college majors and further career choices by students. It may be beneficial to educational researchers who may also utilize factors identified in this study to integrate such factors in quantitative data-collecting surveys to assess relationship of those factors with students' persistence in science. Further quantitative studies can be conducted in the future to determine how strong those factors from high school science experiences are correlated with students' choice of non-science majors. It might be also beneficial to high school science teachers, science faculty and science education faculty to make corresponding changes in their curriculum and instruction based on the findings. It may even further benefit readers who are high school students or university science-major students in the sense that they can use it to reflect upon their own experiences and understandings and strengthen their weaknesses, if possible.

Literature Review

Science Education in the United States

Science education needed. There has been an urgent need for more professionals in STEM fields in the United States for years (Augustine, 2005; National Science Board, 2010). However, the percentage of college students in the U.S. majoring in science were lower than the percentage of their counterparts in other countries (National Science Board, 2014b). Moreover, in the United States 35% of the employees in the STEM work field holding PhDs are foreign-born (Atkinson & Mayo, 2011).

Science education for all or the few? In K-12 settings, “learning science is important to everyone, even those who eventually choose careers in fields other than science or engineering” (National Research Council, 2012, p. 7). In spite of its importance and the nationally set goals to improve science education, a continuous achievement gap in science learning narrowed over time but still existed between White/Asian students as high achievers and Black/Hispanic students as comparatively low achievers. Female students generally achieved slightly lower than male students in science, except Black female students who achieved higher than their male counterparts (National Research Council, 2012; National Science Board, 2014a).

Furthermore, the STEM curriculum was found to vary greatly in K-12 schools among different racial and ethnic populations. Latino students were more often on a lower science curriculum track when compared to their White and Asian peers (Gandara, 2006). Parker (2014) also found that ethnic and language minorities, including the participants in this study, did not have complete interaction with school science and thus were less fluent in science literacy. In light of college experiences, underrepresented students often change their majors from STEM to non-STEM fields or drop out of school completely (Bayer Corporation, 2012). These barriers to science fields in K-12 schools and universities are both unbalanced in race and gender.

Racial Differences

Racial differences existing in high school science experiences. The science-related gap among racial and ethnic minority groups still exists in high schools. Black and Hispanic high school students are less likely to take high-level math and science courses and are more likely to take remedial math, than their White and Asian colleagues (National Science Board, 2014a; National Science Foundation, 2002). As well, the academic achievements of both Black and Hispanic high school students were substantially lower in both math and science than their White and Asian counterparts (National Science Board, 2014a; National Science Foundation, 1999, 2002).

Racial differences existing in university degrees. The science-related gap among ethnic groups also exists in college majors. Hispanics, as one of the three underrepresented ethnic groups (i.e., Blacks, Hispanics and American Indians), constitute a smaller percentages of science degree recipients than they do of the U.S. population (National Science Foundation, 2011). Moreover, the percentage of Hispanics earning science and engineering bachelor’s degrees from minority-serving institutions has declined over time between 2003 and 2008 (National Science Foundation, 2011).

Racial differences existing in science-related career. The science-related gap among racial and ethnic groups also exists in occupations. According to Scientists and Engineers in Science and Engineering Occupations: 2006 (National Science Foundation, 2011), Hispanics comprised 4% and Whites comprised 73%. Hispanic women only accounted for 1% of the population in the science and engineering professions.

Gender Differences

Gender differences existing in adolescents' science enjoyment. The science-enjoyment gap between boys and girls exists early in young adolescence. Riegle-Crumb, Moore, and Ramos-Wada (2011) conducted a survey to both fourth and eighth graders and found that there was no gender difference in science enjoyment in fourth grade and that significantly lower proportion of female eighth-graders reported strong enjoyment in science in comparison to male eighth-graders.

Gender differences existing in high school seniors' major declarations. The science-related gap continues to exist between male and female students in high schools, universities and occupations. Female high school seniors were 60% less likely to choose STEM majors in college than male seniors (Xie & Shauman, 2003). In the same vein, female students are underrepresented in university STEM majors (Simon & Farkas, 2008) and STEM occupations (Blickenstaff, 2005).

Cultural Factors Discouraging Science Identity

In addition to the two influential factors--race and gender, cultural stereotypes also play a negative role for some underrepresented individuals in pursuit of science majors and careers. Science is a part of European male culture (Barba, 1998; Hines, 2003); it is stereotyped as masculine, competitive, individualistic, and isolated (Andersen & Ward, 2014). Many minority students, however, including Hispanic students, prefer collaboration, group work, and cooperation (Ford, 2011; Heilbronner, 2011). Female minority students are also hesitant to integrate science identity into their personal identity because of its double-fold unconformity with their gender and ethnic identities (Archer et al., 2010; Archer, Hollingworth, & Halsall, 2007).

Our Roles

About Us

As the primary researcher in this qualitative study and the research tool to collect, analyze and interpret data, Feng Li held the responsibility for revealing his background information to the participants and readers for them to perceive his potential bias. Feng Li is a Chinese male and Ph.D. candidate in science education with a strong background in science. He received his K-12 public schooling and undergraduate education in China, where the public school system is different from that in the U.S. In China, there is a 3-year high school system requiring that he had to choose to enter either a science track or arts track in the second year of high school study. He decided to choose a science track for four reasons. First, he had a personal interest in science. Since his elementary schooling, he had been interested in science and math for many years. Nature Study was one of his favorite courses in elementary school. In addition, he enjoyed acquiring knowledge and doing experiments in physics, chemistry, botany, zoology, and physiology courses in middle school. Second, the first researcher had his parents' emotional and financial support to develop and maintain his interest in science. His parents purchased many science fiction and non-fiction books for his extracurricular readings. They also liked to take him to zoos, botanical gardens, and science museums in his hometown and other cities in China when they travelled. Third, he had strong belief in his ability in science. Since he entered elementary school, the first researcher was very good at science and math. He has won prizes in national math competitions at both middle school and high school and first prize in a provincial biology competition in high school. His science and math grades were always “A,” and he answered all questions correctly in the high school entrance math exam. Fourth, he planned to pursue a career related to science. Due to his interest and achievements in science and math, he was very interested and motivated to pursue a science career. The high school science track required him to take chemistry and physics for three years and biology for two years, none of which was optional. Even for the arts track, for graduation, students were also required to take chemistry, physics, and biology for two years. The first researcher’s strong science background, particularly his biology background, also comes from his undergraduate major and graduate school experiences. The first researcher went to college in 1998 majoring in biotechnology. After obtaining his bachelor’s degree of science in biotechnology in 2002, he went to New Mexico State University in 2003 and studied in the Master of Science program in biochemistry for one year. From 2008 to 2010, the first researcher pursued his Master of Applied Science degree in infectious disease in Australia. In Fall 2010, he came to Florida International University (FIU) to pursue his Ph.D. degree in biology in the Department of Biology. Then he switched to the Ph.D. program of Curriculum and Instruction, specializing in Science Education, in the Department of Teaching and Learning at FIU in 2013.

As the secondary researcher and author, Dr. Xuan Jiang was involved in the literature review, data analysis, and draft write-up, thus her background might also lead to potential bias. The second researcher was a Chinese female faculty member at St. Thomas University, holding a doctorate in Curriculum and Instruction with a specialty in Teaching English to Speakers of Other Languages (TESOL). She also had her K-12 public schooling and undergraduate education in China, just like the first researcher. The second researcher chose a science track in her second year of high school study. Unlike the first researcher, the second researcher did not have strong self-confidence in science at the time of making the choice. The only reason for choosing a science track was the fact that she would easily earn a higher score at her College Entrance Exam with the science track than with the arts track. When she graduated from high school, her grade in the College Entrance Exam was the highest of all female students in the science track in her school. She took chemistry and physics for three years and biology for two years, all of which were compulsory courses. In her school, students with the arts track were also required to take chemistry, physics, and biology for two years.

Ethical Considerations

The first researcher guaranteed the participants confidentiality during and after the research study. Thus, with their permission, he gave them the pseudonyms of Mary, Nancy and Kate. After approval from the Institute Review Board, and before the participants decided to sign their written consent forms, the first researcher had shown and explained our research study proposal to the participating students. He informed all three participants that he would audio-record all interviews with a smartphone. Before they decided to sign their written consents and right before the interviews, he had shown and explained our written research study proposal to them. He also notified the participants that they could withdraw at any time, if they did not feel comfortable to continue, which would not affect their grades in the class in any way.

The first researcher kept all field notes and audio records confidential and private, that is to say, he was the only person with access to them during and after the research study. During interviews, he asked all of the participants to omit identifiable information to make sure that the collected data had no identifiable information. In addition to confidentiality, the participants were aware of the process, the nature and procedures of the study as well as estimated time for data collection from them before they decided to sign the consent forms. The first researcher also asked those participants to choose a convenient time and place of data collection.

Trustworthiness and Addressed Issues of Bias and Subjectivities

According to Bogdan and Biklen (2007, p. 96), “skin color, race and cultural identity sometimes facilitate, sometimes complicate, and sometimes erect barriers in fieldwork” when educational researchers conduct research studies with people in another ethnic group. Having different racial/ethnical and cultural backgrounds than the participants was one of the key factors inspiring our research interest. Before and during the whole research process with the research topic in mind, we comprehensively considered the pros and cons of the ethnical and cultural differences between the three participants and ourselves. On one hand, it was hard for us to understand their cultural identity, cultural values, and high school experiences in general, due to the different ethnical, cultural, and educational backgrounds. The three participants might not want to reveal some aspects of their cultural values, particularly those that could have negative impacts on their high school science experiences. In order to minimize the possible sensitivity of incoming conversations, the second researcher reviewed some literature about Hispanic culture, particularly literature associated with Hispanics in education. The first researcher showed friendliness and tried to build a rapport with the potential participants when he recruited participants from a TESOL I class and interviewed the three participants. During interviews, when asking questions about their Hispanic culture, the first researcher used a neutral tone and attitude in order to avoid, or at least minimize, their misperceptions of his intention or reference. On the other hand, due to the lack of knowledge in our participants’ ethnical, cultural and educational backgrounds, the first researcher, as the data collector, would not presume that he had already known something about high school students’ biology experiences in the U.S. and tended to ask the participants for richer and deeper information.

When the first researcher interviewed each of our participants and whenever it was necessary, he rephrased what they had just told him to make sure that he had understood correctly and would ask related follow-up questions for more information. He also asked the three participants to check transcripts and his tentative interpretations, to make sure there was no mis-transcription of their answers, as “member checks” (Merriam, 2002a, pp. 25-31), to make sure that there were no misunderstandings or misinterpretations of what the participants had said during interviews. He asked as many of the same questions as possible to the three participants, so that he could compare their answers to different forms of the same question, in order to make sure that the participants had understood the questions and that we could more deeply analyze their answers, according to whether they answered consistently or inconsistently.

To help monitor our bias, we, here in this article, provided information about the level of our science background and different high school system we experienced in China. We also described the research method employed, participants, and settings, in which the data collection procedure was conducted. We hoped through all of these trustworthiness enhancement methods, we could monitor our bias and unconscious judgments along the project to recognize “as to how they may be shaping the collection and interpretation data,” rather than “trying to eliminate these biases and subjectivities” (Merriam, 2002b, p. 5).

When the first researcher began the study, he realized that because of his knowledge with the topic, his subjectivities were more likely to be “shaping the collection and interpretation data” around the topic (Merriam, 2002b, p. 5). Thus, his subjectivities were monitored during data collection through interviews as well as data analysis, aided by applying the following strategies: the first researcher asked the second researcher to independently code the transcripts and then to review his coding in transcripts. Via this peer review, the two researchers agreed to a common coding and developed new insightful coding. As well, the first researcher checked with his critical reflective journal with respect to assumption, worldview, and biases that might affect the exploration (Merriam, 2002a). His reflective journal included his perceptions of his high school science experiences during the time he was conducting this project and his initial presumptions prior to the study. The first researcher initially presumed that math achievements should be closely related to science achievements, however, he found that the interviewees' answers did not support that presumption. Lastly, the first researcher also checked his actual implementation of data collection with his original plan and modified his strategies when the original plan did not work, which helped him see what he needed to do, how he should ask questions in the following interviews and why he made such modifications.

Methods

The primary goal of the study was to explore the relationship between high school science experiences and choice of non-science majors for college studies. To achieve this goal, we chose an exploratory case study as our research design. Case study is an "intensive, holistic description and analysis of a single entity" (Merriam, 1998, p. 27). In this study, "a single entity" referred to three female Hispanic non-science major undergraduate students. They shared the same setting, were enrolled in the same university program and were inherited from the same ethnic culture, thus the case was a "bounded system" (Stake, 2005, p. 444).

Recruitment and Participants

In the sampling process, we employed purposive sampling to select participants for this study. The first researcher talked to an adjunct instructor at a southern Hispanic-serving university and asked her for five minutes in her class where all students were non-science majors, in order to give an invitation speech and explain the research study briefly. The first researcher was granted permission to do so in the class. He explained the research study to the students including why we were going to conduct this research project, what research question this study was trying to answer, how this project would be conducted, and detailed explanation on where and how the interviews would be conducted. The first researcher stated clearly that we wanted to recruit participants who are female Hispanic non-science majors and who had taken at least one science class in high school, because we would like to find some factors that are associated with Hispanic culture and/or female gender role respectively or collectively. At the end of the recruitment speech, the first researcher left his email address and asked those who wanted to participate to email him with their available time.

Seven emails expressing interest in participating were received within 48 hours after recruiting. The first researcher chose three participants out of the seven candidates based on the best match of their available time. These final three participants met the criteria of being Hispanic, female, non-science majors with at least one high school science class, and currently enrolled as an undergraduate student. Thus, they were the most likely to give us the most information from their perspectives about how their high school science experiences influenced their choice of being a non-science major and also some typical factors associated with their Hispanic background and gender role, which is regarded as the "most information about the phenomenon of interest" (Merriam, 2002a, p. 20).

Data Collection

The first researcher was the sole data collector in this study. He scheduled an interview with each of three participants in advance. He conducted each interview according to the scheduled time. Before all of the interviews began, he prepared two main questions to ask the participants based on the research topic. The first question asked for their perspectives was what high school science experiences influenced their choice of a non-science major in college. The second question was whether they think that any of those influential factors were associated with their Hispanic cultural background and/or their gender role as female students. He also prepared some questions about other aspects related to their high school science experiences. The first researcher anticipated asking each of the participants' follow-up questions for details with respect to the participants' own specific high school science experiences. As Rubin and Rubin (2012) described the three characteristics of an in-depth qualitative interview, we chose qualitative interviews as the research method to collect data because we were "looking for rich and detailed information" (p. 29) and "looking for examples, for experiences, for narratives and stories" (p. 29) from the participants about their high school science experiences.

The first researcher interviewed all three participants, in English, on a one-to-one basis, and used digital recording with his smartphone for about one hour with each of the participants. He interviewed Mary for about one hour and Nancy for about one hour, as well. After the first two interviews, he thought that it would be better to review the recorded interview of the first half and to prepare more specific questions for the second half of the interview. Thus, he decided to conduct two 30-minutes interviews with the third participant, Kate, upon her approval. He interviewed Kate the first time for about 35 minutes and the second time for a little more than 20 minutes.

In this study, the first researcher employed semi-structured interviews in a responsive conversation format (Rubin & Rubin, 2012). He asked prepared question such as, "What high school science experiences do you think influenced your choice of a non-science major?" and he also asked the participants to write down on a blank piece of paper some factors from their high school science experiences that they believed to have influence on their choices of becoming non-science majors. This method visually assisted the first researcher in developing and asking follow-up questions according to the factors the participants listed on the blank piece of paper. After he collected enough information about their high school science experiences, the first researcher asked the participants whether they thought any of those experiences were associated with their Hispanic cultural background and/or their gender role as female students. The first researcher modified potential follow-up questions about some specific aspects of the students' high school science experiences each time after completing the interview with the first and second participants as well as after the first half of interview with the third participant, based on the participants' responses during the interviews.

During the interview with Mary, the first researcher felt that she was shy and nervous. Even though he tried to talk with her casually before the formal interview to make her relax, she still spoke vaguely in a low voice during the whole interview. The second participant, Nancy, was less nervous than Mary, because she told the first researcher that she had interview experience before. However, she spoke very fast, which made it hard for the first researcher to understand her during the interview. During the interview with her, the first researcher was considering to ask her to speak slowly, but he was concerned that it might change her usual speaking pattern and make her feel uncomfortable, which might destroy the atmosphere of the interview and ruin the content of Nancy's replies. Thus, he did not stop her to ask her to speak slowly. The third participant, Kate was relaxed during both interviews and spoke very clearly.

Data Analysis

Data analysis in exploratory case study research should be detailed and intensive "for the unit of study" (Flyvbjerg, 2011, p. 301), so that the case study can "represent the case" (Stake, 2005, p. 460). In this study, data analysis began when the first researcher transcribed the first two interviews. The first researcher transcribed the interviews directly from audio records by listening word by word. In the first phase of coding, the first researcher identified distinct concepts related to students' science experiences in the data. In the second phase of coding, the first researcher explored how specific concepts are related and form certain patterns/themes. In the third phase of coding, the first researcher associated the identified concepts and patterns with the context and interviewees' background, and explored how those patterns can be used to answer the research question. Analyzing and coding transcripts of completed interviews gave the first researcher a clearer direction about what to ask for the following interview with the third participant, and also led him to decide to conduct two 30-minutes interviews instead of one one-hour interview with the third participant, which turned out to be a fruitful decision. The first researcher also coded and analyzed the transcripts of the first part of the interview with the third participant to prepare more specific questions for the second interview with her. After all the interviews were conducted, the first researcher transcribed all the audios and sent the transcripts to the second researcher. Next, both researchers independently read through the transcripts looking for key words and phrases concerning the research questions. Once each researcher completed their initial analysis of the data, they created coding categories based on the patterns and topics they uncovered, and then, combined the data.

Writing up the manuscript involved deeper data analysis. We threaded our work with the research question as main themes and framework, and sought answers and evidence from data. We needed to go back and review the data at times. More importantly, we synthesized data with literature review into a whole and complete piece.

Findings

Demographic Information of the Three Participants

All three participants in this research study were female Hispanic students in the same class, all of whom are majoring in Elementary Education. The class was compulsory in their junior/senior year for completing their undergraduate program. Mary was about 30 years of age, and went to high school in Costa Rica. Nancy and Kate were both in their early 20s, and they were born and attended high school in the state of Florida.

The three participants had something in common. Their commonalities were identified and collected through informal conversations prior to the interviews. Then, these commonalities were additionally identified during the formal interviews.

First, they all majored in Elementary Education and planned to be elementary teachers in the future. They all liked to work with children. Mary had two children, and she wanted to gain knowledge about how to teach children who were in the similar age to her own children. Kate worked as an after-school teacher in the elementary school where her mother also worked.

Second, they all had background in art, and they all enjoyed art. Mary started to learn music from the age of five, and she believed that music could be used to improve student performances in other academic subjects. Nancy had a background in painting and drawing. She loved painting and drawing, and even won a prize in a Hispanic heritage competition. Kate liked music and singing. She sang in a church choir and even dreamed about becoming a super star singing on Broadway.

Mary

Mary's background story. Mary is a Cuban descendant in her early 30s. She was born in Cuba, where she went to elementary and middle school. In her teenage years, she moved with her parents to Costa Rica, where she went to high school and obtained a bachelor's degree (i.e., equivalent to an associate degree in the U.S.). She was pursuing her bachelor's degree in Elementary Education at the time of the interview. She had been learning music since she was five years old. She was married and had two kids. One was 9-years-old and the other one was 5-years-old.

Mary's high school science experiences. During the interview, Mary explained that she did not like her high school science classes, because she was required to memorize many concepts in her biology and chemistry classes, which she neither was good at nor liked. She said, "It (biology) was only memorizing all the concepts, names, and I felt I was bad for it, for memorizing. Like too many terms. And I didn't like it…In chemistry, you have to memorize a lot of things." She also expressed concern many times about the teaching styles of her high school science teachers. She said, "It was all about her (the biology teacher) talking all the class. We did not have many like too much interaction… We didn't have like lab that we can experience and you can relate with your life, your real life situation… he (the chemistry teacher) was all the time like teacher do almost all the talking… it was not like very interactive, like we discuss or do groups, no." Her high school science teachers' didactic teaching styles and lack of connecting scientific knowledge with real life made her become not interested in science.

Among all three participants, Mary was the only one who took physics in high school. She said, however, "I don't remember anything in physics," because "they changed the teachers like two or three times…they (the physics teachers) didn't have the same planning…they were changing the content so we were like lost…the teachers were teaching the content we were supposed to know but we were so behind, so we didn't catch it…we didn't have the prior knowledge for that." Due to two or three changes of high school physics teachers in one semester when Mary took high school physics, the course content of the physics class was inconsistent. Mary said that most of students in that class including herself could not catch the content knowledge and failed that physics course.

Mary's choice of major. Mary explained that, because her high school biology and chemistry teachers did not make connections between scientific concepts and real life and she was not good at memorizing those concepts, she was not interested in science. As a result, she was not confident and did not want to pursue a science degree.

Mary's cultural and gender influences. Mary did not talk about the influence of her gender role as a female student in learning science, but she did talk about the influence of Hispanic culture on high school science teaching from her perspective. Based on her experiences in several Hispanic countries, she stated that she felt that Hispanic teachers tended to use a teacher-centered teaching style in that most of the time in classroom it was the teachers talking and the students listening. She said, "From my experiences in not only Costa Rica but in Cuba, the classes were almost like the teacher talking, and not too much interaction… I think that is typical classroom in Latin American countries." When the first researcher asked Mary whether she complained to her high school administrators or principal regarding her high school science teachers' teaching style, Mary said that it was not their culture, and that in Hispanic culture, students were supposed to respect their teachers and should not question or complain about their teachers. She said, "The teacher always…is right." When the first researcher asked, "Was that because of your culture? Students always respect your teacher?" and "do you think that in Hispanic culture, students are not supposed to question teacher?" She agreed and said, "Yes, I think so."

Other factors contributing to Mary's choice of major. Mary said that she had learned music since she was five years old. She had always liked music and wanted to apply music to helping children in other academic areas. When I asked how she could apply music to other academic classes, she used the example of learning mathematics because she explained that music is mathematics in the sense that pianists need to do calculations all the time.

Nancy

Nancy's background story. Nancy is a Hispanic female student at her early 20s. Born in the U.S., Nancy went to high school in Florida. She had a female friend who was very good at science. She had a younger sister. She learned and liked drawing and painting.

Nancy's high school science experiences. In her high school, Nancy was actually good at biology, and she had a good grade in this class. She said, however, "I liked learning about it but I didn't like actually doing it," because she felt that she could not work with blood and she did not like dissection. Blood and dissection were believed to be characteristics of biology and biology-related careers, in accordance with Nancy's experiences and perception in her biology class. She said, "I really like biology actually. I had a good grade on the class. But I noticed that I didn't really like dissection… I can't work with blood…I just can't do that. So that influenced me… When I see somebody with blood I was like I can't. Like I get scared. So I can't. I wouldn't be able to do it." For those reasons, she did not want to pursue any career in biology. Furthermore, in her high school chemistry course, she got a C minus. She said that, in her opinion, her high school chemistry teacher was not a good teacher. She said:

> He (Nancy's high school chemistry teacher) didn't teach…He didn't explain thing thoroughly to the class. Everybody had trouble in the class. He would just sit on his desk and told us to like "go to this page and read that." Sometimes, in class, he would explain usually one example of something and then we had to do the questions from the book. It was really hard. I wasn't really good at chemistry. And he wouldn't really explain. We had bad grades. But he did really practice with us problems on the board or something. And we just had tests like we won't prepare because he wouldn't explain them. So you had to teach yourself. You had to read and understand that, and then tried to see if you could pass the tests [*sic*].

Nancy's choice of major. Nancy felt "discouraged with that (chemistry) class" due to the teaching style of her high school chemistry teacher, and so she decided "not to pursue anything with chemistry." In addition, due to her bad grade in math, she decided that "anything in chemistry, physics, and math. They are not a good choice." Although she received a good grade in her high school biology class, she did not want to pursue any biology career due to some characteristics of biology, from her perception, associated with blood or dissection.

Other factors contributing to Nancy's choice of major. Nancy said that when she considered about her future career choice, she was trying to balance what she wanted to do with a career in which she can make more money. When the first researcher asked her about how she decided what major and what career she wanted to pursue, she used the word "safer." She said she "just go for something safer," which means "things you already know (about) what this career does."

Kate

Kate's background story. Kate was also born in the U.S. and went to public high school in Florida. She is the only child in her family. She liked music, particularly singing. She sang at her church every week. She used to dream about being a star, singing on Broadway. She had a very good friend who was very good at science and went to the same elementary school, middle school, and high school together with her.

Kate's high school science experiences. Kate had the same teacher for both of her high school biology and chemistry courses. She said that she did not like the teaching methods of her high school science teacher. Her science teacher always asked students to read from page to page and then answer questions in the textbook. Kate said that the teacher did not really explain the content to students very well. She described her high school science teacher as follows:

> She was like, "you need to know this to pass the test, you need to know that to finish your assignment to get a good grade"… It (her high school science course) was just like key terms and benchmarks …she never guided us like "OK, you can use this for this (real life situation), or…like it's just cool to know." She just thought like stuff you need to know… She (her high school science teacher) didn't even read the textbook. She just put…problems on the board so I had to go to the textbook to complete. And the whole class was just like "OK. You have to read from this page to this page and answer these questions and turn it in and that's your grade" and that was just my whole high school experiences with science.

Kate's choice of major. Due to her bad experiences in her high school science classes, Kate said that, when she went to college, she did not want to do "anything that has to do with science and math." She used to consider college majors in nutrition or nursing, but, because she had to take chemistry courses for either of those two majors and she did not like chemistry, she had to give up these aspirations.

Kate's cultural and gender influences. Kate, from her perspective, asserted the influence of the cultural history and the social environment on the roles of men and women in science and non-science careers. Kate stated that, particularly in Hispanic society, science and math majors are associated with male students and it is difficult for female students to pursue a science or math major. Kate said that:

> I think that society does… associates teaching with women and like the science and math majors with men. But especially in Hispanic culture, those gender roles are so really inequivalent. … I think that for first generation of Hispanic and Hispanic with (female) gender… hard to go into those majors associated with the other gender.

Kate also talked about different roles of men and women in science or non-science related careers:

> Maybe it's just the society…for example men …when you are in education building and you are a guy, good luck because … (smiling) automatically people think you are a physical education teacher. But I think it can be also historically. Because always women were in the elementary education field, and then men was the one that taking care of engineering and science and all the math.

> Because they…in history, men are always leaders and innovators because women weren't expected to fill that role, and they were more teachers because they were more expected to be nurturing. So maybe it's historical thing and we never really got rid of it.

As to gender difference in learning science, Kate said that:

> I really don't think that there are differences…a lot of people say that men's brains are wider and women's brains are (smaller)…I don't think that's the case. I think that's the environment you are always exposed to. Because…I guess…my best friend she took all the classes as I did. We went to elementary school, middle school, and high school together. And we took all the same teachers. But I always hated it (science) and she always loved it.

However, when the first researcher asked Kate whether she thought that culture, history or social environment had any influence on her decision about the choice of college major, she said that she was not influenced by any of those factors. She explained how she chose a non-science major as quoted below.

> I think my choice was more because of the bad experiences I went to…I want to lead another life and maybe go to the path that gives good experiences because if I had those good experiences I would be on the track to be a nutritionist that I wanted to be. But …I think more it's because of the bad experiences that I had. Because I didn't like it.
>
> My mom was a teacher so I saw her and I liked it. Now I am an after-school teacher for 5th graders and I really love it. So again, it's those experiences that I went through. OK, this was bad so I don't want that. This one was good so I do want that. But I don't think it was because of any gender roles.

Other factors contributing to Kate's choice of major. Kate's mother was an elementary school teacher, and Kate worked as an after-school teacher in the same elementary school. This work experience allowed Kate to acquire insider knowledge of how to work as an elementary teacher. She also felt that she liked to work with children from the same work experience in the elementary school. She said that when she considered her future major and career, she tried to balance what she liked to do with what she could do.

Discussion

The Most Mentioned Influential Factor

All three participants talked about the negative impact of didactic teaching styles of their high school science teachers, in the United States and Costa Rica, on their interest in science. They all mentioned that their high school science teachers utilized teacher-centered and textbook-centered teaching styles, which made them feel bored, confused and not interested in those science courses. For example, Kate said:

> I think it was just the teaching methods I didn't really agree with how she taught it…it was always book work and she never really explained it well. And I didn't really understand what was like the material and what was behind the actual

> content…the way that she (Kate's high school science teacher) taught it, I don't even remember anything. It was always book work and busy work. So I hated it and that's why I got a bad grade because I am a visual learner and I learn with hands-on experiences.

They all talked about their high school science teachers who did not explain course content or science concepts to them very well, did not give them enough chance to have discussions either with the teachers or among students. These teachers hardly gave hands-on exercises or appropriate projects to do and did not take them to any field trips. Most importantly, the teachers did not help them to connect science knowledge with real life. All of the above made them feel that it is hard to understand course content. Consequently, they have no interest in science and any future college majors and careers related to science.

During interviews with all three participants, the most concern they addressed was the influence of their high school science teachers' teaching styles on their science experiences. It was not what to teach but how to teach it that mattered in their cases. This indicated that their high school teachers' teaching styles have a great influence on students' motivation in learning a specific subject and persistence or decision in choosing or keeping in science majors. A didactic teaching style makes students' feel bored in the classroom, gives them hard time in understanding content knowledge, and does not motivate them in learning the subject. As specifically to high school science courses, a didactic teaching style makes students disengaged from the learning process and unable to see the significance of science in real life and to their potential future careers. Bolshakova, Johnson, and Czerniak (2011) from their qualitative interviews found that science teachers' teacher-centered instructional strategies, as well as other traditional teaching strategies, such as teaching students to copy scientific definitions impaired students' curiosity and interest in science. Educational practitioners, particularly high school science teachers, need to pay close attention to this issue, since it is they who could adjust their teaching methods accordingly to better engage and educate students.

Nevertheless, it was interesting that Kate talked about her best friend, who "took all the classes as I (Kate) did," "went to elementary school, middle school, and high school together (with Kate)," and "took all the same teachers (as Kate did)." Despite all the same school experiences they shared, "I (Kate) always hated it (science) and she (Kate's best friend) always liked it." It suggested that it is not science teachers' teaching styles but rather how students perceive and construct their science teachers' teaching styles according to their personal backgrounds, experiences, and prior knowledge that directly influence students' interest, motivation, self-efficacy, and persistence in learning science. It also further indicated that the didactic teaching style of science teachers does not necessarily predict students' low level of interest, motivation, self-efficacy, and persistence in learning science. Nevertheless, it does not mean that teachers' teaching styles are not critical in students' science learning. Teaching style is still important to science learning. As reported by Costa, Van Rensburg and Rushton (2007), an interactive teaching style is more popular than a didactic teaching style, and students in interactive discussion group had higher academic performance than those in a traditional lecture group. A student-centered interactive teaching style may be more conducive to enhancing student interest, motivation, self-efficacy and persistence in science learning more than a teacher-centered style.

Influence of Hispanic Cultural Background and Gender Role as Female Students

Even though all three participants talked about the influence of high school science teachers' teaching styles on their performance and interest in science, none of them went to their high school principals or others who could address the issue to complain about their science teachers. Mary explained that a value of Hispanic culture requires that students show respect to teachers and thus she did not question, let alone complain about their teachers. Mary's answer indicated how Hispanic cultural value in respecting teachers influenced students' science learning experiences in high school.

As to gender role in learning science, Kate talked about the impact of culture, history and social environment on people's choice of career. She said that in Hispanic society, people, both men and women, always say that men are smarter, are leaders and should do things with science and engineering and that women are supposed to nurse others, so teaching is considered more of a career for women. Kate emphasized that such a gender role was more of nurture than of nature. Public perceptions of gender roles had an impact as early as adolescence. Ware and Lee (1988) discovered that female students were less likely to choose science majors in college if they put a high priority on their family life. As a consequence, female students are underrepresented in university STEM majors (Simon & Farkas, 2008) and STEM occupations (Blickenstaff, 2005). On the other hand, male students are untypical in some majors, such as nursing and education.

Kate also mentioned that science is more of a men's business, which echoes the traditional and historical stereotype about science-- male culture, masculine, competitive, individualistic, and isolated (Andersen & Ward, 2014; Barba, 1998; Hines, 2003). Accordingly, many female students are widely impacted by this social value in their choice of college major.

Math and Science Not Correlated

Both Nancy and Kate stated that they were not good at math in high school, and their low self-efficacy and achievements in math made them disinterested and unmotivated in learning science. Nonetheless, according to Mary's experiences in learning math and science, good grades in math did not make her any more interested or motivated in learning science. Mary said that she was good at math, but she did not like to memorize those scientific concepts and did not understand them, particularly those biological concepts and terms. Therefore, even though she was good at math, she still did not like science.

This finding provided evidence from a different perspective to describe the relationship between performance and self-efficacy in math and interest or persistence in science. It also revealed potential bias of the first researcher in this study. Due to the first researcher's own achievements in both math and science and his perceptions about his high school classmates' accomplishments in math and science, he previously believed that students' ability in math correlates with their motivation, attitudes, and achievements in science. In the literature, it was also reported that students' mathematics self-efficacy expectations significantly correlated with their choice of science-based college majors (Betz & Hackett, 1983). Thus, Mary's case should provoke educational researchers to re-think and re-examine the relationship between math performance or self-efficacy and science learning. Good math performance or high math self-efficacy does not necessarily predict a student's science interest or persistence. It is particularly true in some science fields such as high school biology, which does not involve considerable mathematics, but does require significant amounts of memorization. This is also true when a student is either not good at and/or dislikes certain aspects of science learning, such as concept memorization. Synthesizing all three participants' experiences and perceptions in math and science, it is safe to say that low performance or self-efficacy in math may predict students' low interest or persistence in science but high performance or self-efficacy in math does not necessarily predict students' high interest or persistence in science. Some other factors, such as low self-efficacy in memorizing scientific concepts, may impair students' interest or persistence in science, even though the students may be good at math.

Taking Physics or Not?

All three participants took biology and chemistry, but only Mary took physics in high school. Kate and Nancy both said that they were not good at math and, given that they knew that physics required math skills, they did not want to take physics in high school. Instead, they both took biology and chemistry, which required less math skills as they knew. Low self-efficacy in math in Kate's and Nancy's cases was the factor that made them avoid taking physics. Mary was the only one who took high school physics, but remarked that she "don't remember anything in physics" because of the change of physics teachers two or three times in that semester and the inconsistent course content that gave her hard time in understanding concepts in physics. In order to improve high school science education, consistence in content is critical in enabling students to notice connections in scientific concepts and to understand those concepts.

Is Biology Always Associated with Blood or Dissection?

What was interesting and deserving of some attention was that Nancy associated a biology career with blood and dissection, which scared her away from pursuing a biology degree and a biology-related career. When it comes to misconceptions about biology and a biology-related career including the notions that Nancy expressed, it may be worthwhile to reform high school biology curriculum to address those misconceptions and demonstrate what biology really looks like. Clearing up such misconception could help retain those students who, like Nancy, are frightened of blood or dissection, by explaining to them that biology is not all about blood or dissection. In fact, many fields in biology and many biology-related careers are not associated with blood or dissection at all.

Relationship between Performance and Persistence in Science

Nancy's experiences and perceptions about biology provided a new perspective to consider regarding the relationship between students' performance and persistence in science. Nancy was "good at biology" and received a good grade, but she only liked learning biology, but did not like "actually doing it," due to her fear of blood and dissection which she associated with a biology major and a career in biology. This finding provided evidence to demonstrate that high performance in science learning might be necessary but not sufficient in motivating students to persist in science and to pursue a science-related major and career. Actually, Nancy did not experience any experiments or activities involving blood or dissection in her high school biology class. Her misconceptions about biology may have come from the social environment, such as her parents' words or media messages. She constructed information from the social environment to form her own knowledge (perceptions, opinions, misconceptions) about biology and biology-related careers. This critical factor negatively impacted her persistence in biology, her interest in pursuing a biology major and a biology-related career, even though she had performed well in her high school biology course.

Concluding Thoughts

This study explored factors from three participants' high school science experiences, which from their perspectives, influenced their choice of non-science undergraduate majors. We intended to answer the research question, that is, "what high school science experiences of three female Hispanic non-science major undergraduate students influenced, from their perspectives, their choice of a non-science major?" We found that their perception and construction of high school science teachers' teaching styles played a decisive role in negatively influencing their interest, self-efficacy and persistence in learning science and their further intention to pursue a science degree in college. We also found that they all believed that connecting science knowledge with their real life could have made them more interested in science, but their high school science teachers failed to do so, or did not apply sufficient effort to do so. As to the influence of three participants' gender role as female students on their science learning, none of them mentioned that there was any advantage or disadvantage as a female student in learning science; however, Kate mentioned social pubic expectations on careers varying in genders (i.e., science as male-favored). When it comes to the influence of their Hispanic cultural background on their science learning experiences, Mary talked about the Hispanic tradition that students should not complain about their teachers in public, and Kate talked about the influence of social cultural environment on people's opinions and choice of career according to whether it is science or non-science related. However, Kate did not agree that she was influenced by this kind of social cultural environment.

Limitations

All participants of this study were recruited in an education class at the undergraduate level and they were all majors in Elementary Education. This might bring some bias to the current study in trying to find connections between participants' high school science experiences and their choice of a non-science major in that their perceptions of high school science experiences and reasons to choose Elementary Education as a major might be different from students in other non-science majors.

In the current study, moreover, we did not differentiate among science courses from those with advanced track in high school. The two levels or tracks might count for Non-STEM and STEM pipelines for college majors and future careers.

Practical Implications

This qualitative study explored the high school science experiences of three Hispanic female non-science major undergraduate students and, from their perspectives, how their high school science experiences influenced their choice of non-science majors. The most frequently mentioned influential factor among three participants was the didactic teaching styles of their high school science teachers. Education practitioners, particularly high school science teachers, may learn from those descriptions of negative teaching styles (i.e., don'ts) and the participants' learning experiences to improve their science teaching strategies and to address students' needs in high school science classrooms (i.e., by using more dos), or in high school courses, in general. It might also inform high school science teachers of some factors that influence students to choose science majors and that can be applied to improve high school science education. At the same time, consideration must be given to some other factors that affect students choosing to avoid science majors and recognition of the pressing need for awareness and reformation.

Thoughts for Future Research

Educational researchers may use information from this qualitative study to develop surveys about students' high school science experiences in and out of science classes to collect quantitative data for further quantitative analysis to determine correlations between factors from students' high school science experiences and their choice of college majors. With results of quantitative correlation analysis, regression models can be developed to predict high school students' choice of college science or non-science majors based on factors from their high school science experiences.

In order to enhance the trustworthiness of research studies as such, future researchers could recruit and interview participants from non-science majors, other than Elementary Education to seek wider viewpoints regarding high school science experiences. It will also be interesting to interview participants from STEM majors and to compare their experiences and perceptions about high school science experiences with those of non-science major students. It can further help educational researchers to probe answers into some more questions, including the differences in academic and career choices among individuals of similar/same educational backgrounds and high school science experiences.

All participants in this study had art backgrounds. They all learnt art, such as piano, painting, and singing for years and were engaged regularly in art-related activities. It might be interesting to examine the relationship between students' art backgrounds and their interest or persistence in science, as well as their choices of college majors.

Because Nancy mentioned that it was her fear of blood and dissection that made her avoid choosing and pursuing a biology major and a biology-related career, despite not having any experiences of experiments or activities that were associated with blood or dissection in her high school biology class, it would be worthwhile to identify sources of misconceptions about biology, and in general about science, particularly those that could be frightening students away from learning science and pursuing science majors and science-related careers. No matter what the source of such misconceptions is, it is worthy addressing this issue and assisting students in developing a holistic and neutral viewpoint toward science before they have to make decisions to pursue science majors or not.

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