Science Identity, Major, and Gender Influence Persistence in Interdisciplinary Program Focused on Complex Global Issues

Katherine Malyszek

University of Florida

Abstract

With the push for students to enter STEM fields to help us address future complex problems due to an increasing global population, it is important to analyze the factors that guide someone in determining their future career path. The Global Leadership and Change Certificate (GLC Certificate) at the University of Florida brings together high-achieving students from 29 majors, both STEM and non-STEM disciplines, to solve such problems, providing an interesting case study to examine one factor in career decision making, science identity. According to Carlone and Johnson, science identity is the confluence of competence, performance, and recognition, with many academic and social influences specifically in the context of science. GLC Certificate students were surveyed about their science identity and demographics. Based on willingness determined by survey responses, participants were interviewed. Interviews were coded and thematically analyzed to determine the factors that develop one's science identity, how this leads them to self-select into the GLC Certificate, and if this affects males and females differently. The researcher found GLC Certificate students have an average science identity score of 3.496, which is in the medium range of science identity (3-4) and that there is no difference in science identity scores for males and females in the GLC certificate program. It was also found that two themes determine science identity, experiences and influences. Persistence in the program was found to be affected by its relevance and interdisciplinary studies. The results of this study will allow better recruitment of individuals who do not consider themselves to be a science person to help solve the complex problems the world will be facing.

Science Identity, Major, and Gender Influence Persistence in Interdisciplinary Program Focused on Complex Global Issues.

By the year 2050, the global population is expected to reach 10 billion individuals. Coupled with this growing population is a growing demand for people to help solve the population related issues dealing with agriculture, transportation, limited resources, and environmental problems, to name a few. More students will need to enter STEM related fields to address the future complex problems we face due to an increasing global population (Carnevale, Smith, & Melton, 2011). As a result, it is now more important than ever that we analyze the factors that guide someone in determining their future career path, specifically those that guide them into STEM related careers.

The Global Leadership and Change Certificate (GLC Certificate) at the University of Florida brings together high-achieving students from 29 majors, both STEM and non-STEM disciplines, to solve such problems that accompany a growing population. The GLC Certificate is comprised of ten credits divided among four courses. These courses are put in a suggested order of: Global Uncertainty, Developing Tools for the Changing World, The Experience, and Creating Solutions. The Experience is an internship or study abroad component while Creating Solutions is a capstone project course. The GLC Certificate program is 68% female and 32% male and has students representing ten of eleven undergraduate colleges with an average GPA of 3.58. Focusing on this population allows us to better understand the factors that lead someone into this field, and will allow for improved recruitment methods (Andenoro, Sowcik, & Balser, In Press). This certificate program provides us with an interesting case study to examine one factor in career decision making, science identity.

Literature Review

Identity and how an individual develops his or her own identity has been researched among various demographic groups, but little research has been done on how an individual develops their science identity during undergraduate years, and how their gender and science identity affect their future career goals. The study of science identity among a student group with diverse majors in a certificate program focused on global problem solving will allow researchers to determine factors that lead people to pursue STEM or non-STEM fields, critical for future support for employees in these careers for the future.

Many internal and external factors work together to create one's identity, one's overall conceptualization of the self. An internal factor is self-efficacy, which is a person's belief that they are able to master events in their own life (Bandura, 1978), so academic self- efficacy is one's confidence in their ability to accomplish academic tasks. An example of an external factor influencing identity is the opinion of others. The amount of influence someone has on a person may vary based on the source's relation to the individual (Astell, 2000). Identity is developed individually, but social situations also mold a person's identity (Brickhouse, Lowery, & Schultz, 2000). This affects educational interests and how people judge themselves (MacPhee, Farro, & Canetto, 2013). This relates to science identity as academic self-efficacy determines how someone views himself or herself and their abilities.

Carlone and Johnson (2007) define science identity as a sense of self at the confluence of competence, performance, and recognition, with many academic and social influences specifically in the context of science. Identity is flexible; it goes through changes until an individual becomes committed (Schwartz, Klimstra, Luyckx, Hale, & Meeus, 2012). There are many factors, both internal and external, that influence identity. These include self-efficacy or a

person's belief that they are able to master events in their own life (Bandura, 1978), parental involvement (Toren, 2013), academic successes and failures (Toren, 2013), social situations (Astell, 2000), and gender differences (Wang & Degol, 2013).

Factors that play into one's academic identity may be similar to ones that influence science identity. These factors include parental educational involvement, whether that is at home with homework and sharing beliefs about education, or at the school volunteering around campus or in classrooms. These increase children's academic achievement and thus improve their self-competence (Toren, 2013). Another factor involves social norms and how these influence someone's academics. Students learn that their academic performance influences their acceptance or rejection by social domains, thus impacting their academic focuses. When students with an academic propensity are rejected socially, they tend to delve deeper into academics (vanDellen, Hoy, Fernandez, & Hoyle, 2011). These academic experiences, positive or negative, influence a person's science identity and how they view science. Carlone and Johnson (2007) conceptualized science identity as the confluence of competence, performance, and recognition, encompassing many of these academic and social influences specifically in the context of science.

Identity goes through changes until an individual becomes committed. Identity is flexible and is a culmination of many life events. Early adolescents lack identity commitments due to internalization of problems. If identities have been formed, adolescents may have enacted these identities without exploring all options. People reconsider their identities on an as needed basis due to dissatisfaction with one's self, increased anxiety, or a lack of consistency. If one is making functional decisions, reconsideration is not likely (Schwartz et al., 2012). This can be applied to one's science identity and how it is fluid, and identity's influence on career decisions.

When someone is not confident or is anxious about their abilities, it may lead them to reconsider their science identity. For example, if someone considers himself or herself a science person and then they do not pass a general education STEM class, he or she might reconsider their views toward science and ultimately, their career.

There are also gender differences surrounding STEM fields that may reflect science identity. Females tend to do better than males in the STEM fields in high school but at the undergraduate level, far fewer pursue the STEM fields (Wang & Degol, 2013). If a male and female have similar math aptitudes, the female is likely to have better verbal skills (Wang & Degol, 2013). This might give women the option for more career options, not just STEM related fields. Females also tend to be more altruistic causing them to focus on fields dealing with people rather than objects (Wang & Degol, 2013). Women also tend to perceive themselves as weaker academically even when scoring similarly to males (MacPhee et al., 2013).

In order to study these factors of science identity, this thesis will focus on Global Leadership and Change Certificate (GLC Certificate) students. The GLC Certificate at the University of Florida is a multidisciplinary adaptive leadership program that brings students together to solve problems of a changing world with a growing population, with a heavy emphasis on evaluating agricultural and scientific solutions. These students are all high-achieving individuals who self-selected into this program. This program has people from 29 different majors, 10 out of 11 undergraduate colleges at the University of Florida, and a 3.58 GPA, but twice as many females as males (Andenoro, unpublished data). Little research has been done on what draws students to this type of program and how science identity comes into play. The GLC Certificate brings both natural and social sciences together with leadership theory to prepare students to deal with problems of the changing world.

This study had a three-part objective. To start, the researcher wanted to determine if gender differences in science identity exist. In addition, the researcher aimed to determine what factors develop one's science identity, especially in people who do not have STEM majors but pursue certification in this program that is heavily dependent on evaluating scientific solutions. Lastly, the researcher hoped to determine whether science identity plays a role in persistence throughout the program. By focusing on these objectives, this study will allow better recruitment of individuals who do not consider themselves to be a science person to help solve the complex problems the world will be facing.

Methods

Participants

The researcher recruited participants from the Global Leadership and Change Certificate program, a certificate program that consists of three courses and a study abroad or internship component. Students from the introductory course, ALS 2410, a more advanced course, ALS 3415, as well as the capstone course, ALS 3940, and students who have completed the certificate were census surveyed.

Materials

The survey asked about willingness to be interviewed, and those who agreed were interviewed at a later date. The survey used Likert-scale items around the three areas identified by Carlone and Johnson (2007), adapted into a 12-question survey by Wolfe (2013). Questions were asked about connections to science, views about science, major, future career, and standard demographics. The science questions allowed science identity scores to be determined. The demographics asked included age, ethnicity, gender, year in school, and point in the program. In conjunction with questions about major and future career, participants were asked if they

considered their major and intended career to be a STEM or STEM related field.

The interviews consisted of 20 questions centered around the role science played in the participants' lives, how they came to develop their views on science, and how science identity has affected their future career. They were also asked questions pertaining to the GLC Certificate. These questions focused on their motivations for enrolling, their thoughts on the program, the impact they think can be made through the program, and how science and non-science topics are used in this program.

Design and Procedure

The design of this study included two portions, a survey followed by an optional interview.

The survey was distributed to all members of the GLC Certificate, with response being voluntary. Dr. Andenoro, a professor in the Global Leadership and Change Certificate, had the link to the survey that was on qualtrics, along with the recruitment email sent to the listserv of everyone in the program. This was done to get a thorough sample of the students in the recruitment population. The informed consent for the survey was completed in qualtrics before the participant was able to complete the rest of the study. The survey began with the informed consent then moved on to Likert-type questions about the participant's perceptions on science, then demographics. Participants were then asked if they would be willing to complete an interview, if they agreed, contact information was also provided.

The survey was sent to 114 people, with ten survey responses. Due to a low response rate for the surveys, the researcher extended interviews to all survey respondents who indicated they would be willing to be interviewed. Of the ten people who participated in the survey, six people agreed to be interviewed, and all six participants completed interviews.

Those who agreed to participate in an interview were then contacted and scheduled. Interviews were completed online through Google Hangouts or in person, depending on the participant's preference. The interviews were semi-structured and followed the interview protocol found in the Appendix. Interviews were recorded and notes were taken to be transcribed and analyzed.

Data Analysis

Surveys were used to analyze science identity scores. These scores were determined by finding the average of the Likert-type questions. Each answer choice was given a number used for scoring purposes. An answer of strongly disagree was scored as 1, increasing by one with each response to 5 when an answer of strongly agree was given. All of the answers given by a person were averaged and this was the science identity score. The science identity score ranges are high (4-5), medium (3-4), low-medium (2-3), and low (1-2), based on groupings by Wolfe (2013). Along with averaging the answers given to find science identity scores, standard deviation was also found to gain more descriptors about the participants' science identity. Demographic information such as major, gender, and most recent GLC Certificate course taken were then analyzed alongside science identity scores.

Interviews were analyzed through the coding of transcripts from the recordings (Miles & Huberman, 1994). The codes formed through this data analysis were done to categorize similar pieces of data from the interviews. This was done in accordance with Miles and Huberman's Qualitative Data Analysis. Coding was completed through both emergent and expected codes (Bogdan & Biklen, 2007). Expected codes came from pilot data (Wolfe, 2013) from a previous unpublished study on science identity (Malyszek et al., unpublished). Emergent codes originated through the analysis of data from this study. Codes such as applied science, leadership, and

social understanding were grouped into themes such as interdisciplinary study.

Bias

The researcher was a participant in the first course of the certificate program at the time of survey, but not at the time of the interview, contributing to their bias. This caused the researcher to form assumptions about the types of responses that participants provided. Certain codes were expected prior to interviews based on knowledge the researcher gained while in the class. This course had a specific vernacular that the researcher had in mind when creating interview and survey questions. Partaking in daily discussions gave the researcher insight into the kinds of questions to ask participants because of previous interactions with students in the Global Leadership and Change program.

Taking the first course of the certificate program provided the researcher added insight into the program allowing a more effective analysis of data. In the Global Leadership and Change certificate courses, there are commonly used words or phrases and their associated definitions that students are familiar with which may not be common to someone outside of the program. This includes terminology such as adaptive leadership.

The thesis advisor for this study is a researcher in Agricultural Education and Communication who has done previous research on science identity. This has provided the undergraduate researcher with added knowledge on the subject. A professor in the GLC certificate program has also provided background information on leadership theory and publications within the leadership field. Through association with these advisors, the researcher was able to have a well-developed background on the information that may arise in this field.

Results

The results of this independent study come from a three-tiered analysis based on the research objectives using both survey and interview data. Survey data provides a framework to understand the population being studied. Through the interview portion of this study, the researcher found several overarching themes emerged from the data, which were broken into codes as well as described and supported through specific examples.

Participant demographics

Nine undergraduate students and one graduate student in the Global Leadership and Change Certificate participated in this study. Of these ten students, four were male and six were female. Out of the ten to participate, six agreed to be interviewed, with 50% being female and 50% being male. Three survey participants, or 30%, had a high science identity (4-5), four had a medium identity (3-4) or 40%, two had a low-medium identity (2-3) or 20%, and one had a low science identity (1-2) or 10%. The participant population consisted of Caucasian (70%), Hispanic/Caucasian (20%), and African American (10%) individuals. These participants consisted of both STEM (60%) and non-STEM (40%) majors who were pursuing either non-STEM (50%) or STEM-related fields (50%), with not all STEM majors pursuing STEM-related fields. A wide range of majors were represented in this study, as a wide range of majors are represented in the GLC certificate program. Represented majors in this study include political science, psychology, neuroscience, business, environmental science, computer science, information systems, leadership development, and plant science. Participants were pursuing careers such as law, medicine, academia, software engineering, and conservation, with some participants unsure of the career they would pursue.

Interview participant profiles

There were six participants interviewed and each was given a pseudonym. These participants will be called participants 1, 3, 4, 8, 9, and 10. Participant 1 or Anna is a non-STEM majored female with a science identity of 2.67 studying political science and information systems. Participant 3 or Amanda is a female STEM major with a science identity of 3.55 studying environmental science. Participant 4 or Olivia is a female STEM major with a science identity of 3.5 studying neuroscience. Participant 8 or Rick is a male non-STEM major with a science identity of 2.42 studying leadership. Participant 9 or Dave is a male non-STEM major with a science identity of 3.75 studying political science. Participant 10 or John is a male STEM major with a science identity score of 4.83 studying plant science. These participants opted to participate in the optional interview after the survey.

Objective 1

As the first objective, the researcher wanted to determine if gender differences in science identity exist in this population. Through analysis of the survey based on gender. The average science identity of females was 3.17 with a standard deviation of 0.77. The average science identity of males was 3.64 with a standard deviation of 0.99. Through a two-sample t-test assuming unequal variances, the researcher determined there was no statistically significant difference between male and female science identity scores with an alpha of 0.05. The two-tailed p-value was 0.279. The researcher realized that the sample size was limited and that a non-parametric test might ultimately be better suited for this small population, but since the t-test resulted in no difference between males and females and is a less conservative test, a non-parametric test was not run.

It was found that two males had a high science identity while one female had a high science identity. One male had a medium science identity while three females had a medium science identity. One male had a low-medium science identity while one female had a low-medium science identity. No males had a low science identity while one female had a low science identity. Of the males, two were STEM majors pursuing STEM-related careers and two were non-STEM majors pursuing non-STEM careers. The two males with high science identities were pursuing STEM degrees and careers. The medium and low-medium science identity scoring males were pursuing non-STEM degrees and careers. Of the females, four were non-STEM majors and two were STEM majors. Three of the four females with STEM majors were pursuing STEM-related careers and the other three females were pursuing non-STEM careers. The female with high science identity was pursuing a non-STEM degree in business with a focus in sustainability studies and was undecided what non-STEM career path she would pursue. The three females with medium science identities were all pursuing STEM-related fields. The two females with a low-medium and a low science identity were both pursuing non-STEM fields.

Objective 2

The second objective of this study was to determine what factors develop one's science identity, especially in people who do not have STEM majors but pursue certification in this program that is heavily dependent on evaluating scientific solutions. Data from this objective were from both the survey and the interviews.

When analyzing science identity scores in conjunction with intended field of study, the researcher found that two of three high science identity scoring participants were pursuing STEM degrees and two out of four medium science identity scores were pursuing STEM degrees. For both the low-medium and low science identity ranges, participants were all pursuing

non-STEM degrees. All of those who said they were pursuing non-STEM degrees also reported they were pursuing a career that is not STEM related. Of the four participants who are pursuing a STEM degree, three reported they were planning on entering a STEM career. The participant who reported they were a STEM degree student who is pursuing a non-STEM field had a medium science identity score.

When participants were asked how they define science, there were commonalities among the responses. Participants viewed science as more than the 'typical' science fields such as chemistry, biology, and physics. They viewed science as more of a process rather than a subject. For example, science was defined as a body of knowledge, the process of asking or questioning, and the accumulation and development of knowledge. These definitions of science defined science as something that you can practice in your everyday life rather than a career or subject area. John said that "pretty much everything falls into science in some way shape or form."

After being asked to define science, participants were asked if they believe this is how most people would define science. Participants responded saying that others would not define science the same way as them or that at first people would not think of science as their definition but would agree with the definition upon hearing it. Further research should be done on this to see if this view of science is unique to students in the GLC certificate, if they had this definition of science before entering the certificate, and if people outside of the certificate hold this definition as true.

With participants classifying a wide range of subjects under science, some sub-divisions arose in the definition of science. The typical fields considered as sciences included biology, chemistry, and physics. These were often described as the natural or physical sciences. The social sciences were also mentioned and included fields such as leadership development,

anthropology, sociology, education, and psychology. Anna also discussed how fields such as the arts, such as glass blowing, have scientific principles behind them and this would fall under STEAM. STEAM is science, technology, engineering, art, and math. This is a movement of including the arts into the traditional definition of STEM due to underlying scientific methodology. Anna stated that "there are so many techniques you learn through any science class such as how do you formulate a hypothesis and create an experiment that is in the traditional science track but in the arts there are things that you learn and then apply." This application of science to the arts was also seen when participants described the science behind other fields.

Participants also made a differentiation between science and STEM, leading the conclusion to be drawn that science has two working definitions as either a subject or a process. STEM is defined as science, technology, engineering, and math. When asked if Dave's political science degree was a STEM degree, the answer was no but when asked if this is a science, the answer was yes. This also happened with Olivia who wants to use her neuroscience degree to go into educational and evolutionary neuroscience. She said that this field has scientific applications but is not "the typical STEM." These bring to light underlying connotations about STEM related fields. There is a stigma around STEM-fields that make them seem unattainable or challenging. There is also the connotation that STEM-fields do not involve a human dimension. This was brought to light when Amanda said that she was getting a BS in environmental science but wanted "do a more applied social science focus, more human dimensions." Responses like this show that in order to increase participation in the STEM fields, a rebranding is needed to show their applications to the 'real world' and how they impact human dimensions and social structures.

Through the coding of interviews, several themes emerged around the development of science identity. These include experiences and influences. These themes are broken into codes that provide a more nuanced explanation of the development of one's science identity.

Experiences. Throughout the lives of the participants, occurrences happened that helped to shape their identity as a scientific person and views about science. These are brought under the theme of experiences. Participants detailed a variety of experiences that impacted their science identity, which can be separated into four categories: personal experiences, anecdotal experiences, involvement, and educational experiences.

Personal experience. Participants detailed experiences that occurred in everyday situations that allowed them to develop views of science. For example, as a child John spent a lot of time outdoors doing miscellaneous activities. One day he was flying a kite and decided to jump off his family's old horse trailer while holding the kite. He explained how this method of trial and error is what brought him to science. Science provided an outlet for his inquisitive nature, leading him to pursue science as a career. This informal experience was self-guided and did not have structure, it was just a normal day to day activity for him.

Anecdotal experience. A key experience participants brought up when discussing the development of their science identity was hearing about the experiences of other people which caused them to feel a certain way about science. These anecdotes were not meant to sway them towards or away from science but were rather used in conversation and the participant found meaning in them. This is the learning and developing through the experiences of others. For example, Amanda's father is a lawyer that deals with car accidents so in court cases he brings in doctors and physicists to explain why certain things happen in an accident. Learning these science concepts through his non-science based job and finding it fun makes him wish he had

taken an alternate route. Hearing stories about this from her father's regrets inspires her to keep learning science in her college curriculum. Another example of anecdotal experience comes from Anna. Her dad has a PhD in aerospace engineering, making him a rocket scientist. She felt like she could never compete with that so she decided to find her own pathway outside of science but still wanted to incorporate what he had taught her about science.

Educational experiences. When asked questions pertaining to the participant's development of science identity, classroom experiences were often mentioned. These experiences are both academic performance related and curriculum related. In regard to academic performance experiences, when a participant receives poor grades in the sciences, it played a role in lessening their view of themselves as a science person. For example, Anna mentioned how as a child she did not do well in the sciences so she was scared of them. This was attributed to her fear of failure, causing her to be intimidated by the sciences that she had once failed at. The curriculum aspect of educational experiences focuses on how the subject matter influenced science identity. For example, Olivia became interested in science because she loved doing experiments and always found them fascinating, causing her to pursue science camps and now a science degree.

Influences. Another theme the researcher found through the interviews includes influences which are external pressures that caused the participant to view science a certain way. These influences include parental, societal, academic influences.

Parental influence/expectation. Through the developmental years and college, participants are often influenced by their parent's thoughts about science. Parental abilities and perceptions play a large role in how their child's science identity is developed. Five of the six participants interviewed mentioned parental influence as a source of their views on science.

Parental influence both led people to and away from science. For example, Amanda's parents were both in a non-STEM field as lawyers but convinced her to pursue a Bachelor's of Science in Environmental Science rather than a Bachelor of the Arts because they felt it would provide more opportunities for her, even though the B.A. aligned more closely with her career goals.

Societal influences. Societal influences are the impact that a person's peers have on their science identity. For example, when Dave was in his early years of schooling, there was a stigma present around science and being good at it. Science not being cool while sports and video games were, made him gravitate away from the sciences and towards what society was telling him was cool. John stated "I think people respect science. I think people from educated and uneducated backgrounds encourage their children to know and learn about science because they know it is important." This is an example of how society influences our perceptions of science and how parents transfer societal beliefs to their children.

Academic influences. The views of the teachers and school a participant attended also influenced their views on science. For example, Rick attended private school were a well-rounded education was promoted. While he did not end up pursuing a STEM-field, he had a deep appreciation for the sciences. An example of teacher influence is exhibited in Amanda who had low self-esteem causing math teachers. These teachers led her to believe she was not good at math but when she got to college she took calculus and physics and realized she was not bad at STEM courses.

Objective 3

The final objective is to determine how science identity plays a role in persistence throughout the program. Analyzing this objective requires data from both the survey and interviews. The interview participants had a wide range of science identity scores from 2.42 to

4.83. These scores occur in the low-medium through the high range for science identity. This range of identities allowed the researcher to have a snapshot of the overall science identity score for participants at a particular moment in the program that could then be analyzed in conjunction with interview questions about student's persistence through the program. Of those who took part in interviews, three were STEM majors and three were non-STEM majors. There were also three males and three females. No one with a low science identity agreed to participate in an interview.

How the participants came across the Global Leadership and Change certificate all differed but there were common themes as to why they decided to pursue more coursework in the program. John, a plant science major, has a specialization in sustainable crop production and the first course in the certificate, Global Uncertainty, was required for his degree. While this class was required, he decided to self-select into the other certificate courses. Rick and Dave heard about the certificate through the Leadership minor. Olivia took the first class in the certificate after reading about it in the schedule of courses during freshman orientation and later decided to complete the certificate. Amanda heard about the study abroad component of the certificate, leading her to take the first class, and then pursue the certificate. Lastly, Anna was drawn to the Global Uncertainty class because of her academic focus on international development. She then decided to continue with the certificate program and was asked to TA for it as well.

Through interview questions pertaining to science and the GLC certificate, certain themes about persistence in the program arose as well as a common definition of science among the participants.

Interdisciplinary study. A common reason students are in this certificate program is the multi-disciplinary approach to learning. Students like how the certificate courses synthesize lessons they have learned from previous courses and life experiences to provide them with a well-rounded education. Rick described this theme well by saying "the marriage or unification of those two ideas is where we will create complex solutions to complex and adaptive problems."

Applied science. Applied science is taking scientific concepts learned and putting them into practice in the "real world." This practice is frequently mentioned as an important aspect of this certificate program by participants. For example, Anna was talking about how most science courses as you to memorize and practice these concepts to then apply them to quizzes, but the GLC courses ask you to do research, formulate opinions, and have open discussions about these topics so you can apply what you have learned to issues we are facing today. Anna is a non-STEM major and enjoyed the GLC certificate courses because she was exposed to science but not asked to simply memorize facts. She describes how the approach to science in these courses can be applied elsewhere by saying, "I think the sharing of opinions is important because that is really what a lot of the scientific community does, share opinions. There is some evidence to back them up, but there is evidence on both sides so that I have grown my perspective on what science is." John also demonstrated why he liked the science in the GLC certificate courses, saying, "I feel like a lot of the time people take very generic classes and expect them to like science but they never get to analyze ideas for themselves like we to in that class. They never get to take their scientific understanding to a meaningful applied context." This illustrates how the GLC courses provide students a way to think deeper about the material they have learned and apply it to real world problems.

Social understanding. The Global Leadership and Change certificate program incorporates a social aspect to the study of science-based problems. It involves being aware of the implications of actions on societal structures when making science based decisions. John stated, “I think there are many of these scientific issues that have social consequences and social derivatives.” This social awareness ties directly to the social system discussed in the GLC courses. He also said that he likes science classes with a social aspect to them like the GLC courses because you are basing things on scientific data and that has implications on the social aspect of the world. Many participants such as Amanda want to focus on applied social sciences and human dimensions, which is the unification of social awareness and science.

Leadership. This certificate program also provides a link between leadership and science to help solve complex issues. Participant 8 said “It is cool because the application of leadership to real world problems will create these intersections where we create these really cool solutions for the world” in reference to the Challenge 2050 project and GLC Certificate.

Unification of the sciences. The GLC certificate is interdisciplinary between the science fields. It focuses on unifying all sciences to solve complex problems. Rick said, “using science in its various forms of natural vs. social ... The marriage or unification of those two ideas is where we will create complex solutions to complex and adaptive problems.” This certificate program promotes the idea that no science is more important than another and that all are needed when problem solving because they are intertwined.

Relevance. Global Leadership and Change certificate courses cover a wide range of material which is broken into five systems: health, food, economics, social, and environmental (Andenoro, unpublished). Using these five systems allows students to understand the interconnectedness of processes that influence and work with one another to impact the whole.

This is called systems thinking (Senge, 1990). This causes students to better understand the relatedness of issues and that they cannot view one issue without addressing another. This also makes these issues relevant to students (Andenoro, unpublished).

Educational relevance. A common praise of the certificate program was that it related to the participant's major and allowed them to better understand and apply the information they would otherwise be learning as well as understand the importance of knowing the material. Dave stated that "Challenge 2050 encompasses all sciences, not just the remedial definition of science," meaning that the GLC certificate program is relevant to all sciences, from the natural sciences to the social sciences. Olivia said that the GLC courses made her find biology more interesting because it made the material relevant to her rather than just memorization. She also stated that "these classes are the reason I am interested in science. When I was younger it was the cool experiment aspect and now it's actually relevant to helping the earth."

Personal relevance. Another praise of the certificate courses is that they are relevant to addressing common issues heard about and experienced outside of the classroom. For example, when speaking about the second course in the certificate, Developing Tools for the Changing World, John spoke about how in class they learned there are no broken systems. He further clarified that in class, they were discussing systems such as a political or social system and how it is often said that the system is broken and needs to be fixed, but this is an inaccurate statement because a system is not broken when it no longer suits your changing needs. He said, "you can't fix something that was never originally there." This sentiment resonated with him because he has been able to apply this knowledge to discussions he has and works that he reads, and thus it contributes to his self-awareness. This participant also mentioned how these classes "are an

exercise in problem solving" and "calculated argumentative skills." He said these skills apply to group management and teamwork and provide students with a better global understanding.

Global relevance. When asked about solutions to the complex problems our world will be facing with a growing population, participants mentioned that science would play a huge role in solving them but only if communication of science was prioritized as well. Amanda said, "I think by itself science is not enough" and continued on to describe how you need the scientists who do this research but you also need middle grounders to be able to convey this research to others and make them care about it or else no one will realize we have an issue or the significance of the solution. Anna said "It's everything, it's honestly everything. It has a lot to do with cooperation as well though… even if we perfect the science, I fear that without just the humanitarian connection there is not going to be any change made. People need to understand one another and want to work together. They need to be motivated to find a solution in order for that science to matter. But communication is the key."

Discussion

Through this study the researcher aimed to determine if gender differences in science identity exist in this population, determine what factors develop one's science identity, especially in people who do not have STEM majors but pursue certification in this program that is heavily dependent on evaluating scientific solutions, and lastly, determine how science identity plays a role in persistence throughout the program.

The limitations of this study include the small participant population. 10 surveys were completed and 6 interviews were conducted. The six interviews yielded similar results in terms of motivations for participation in the certificate and definitions of science. Another limitation of this work is that the data is qualitative and the population size is too small to run statistical tests

on the survey data that can be quantified. Because the response population was small and interview participation was optional, there are few examples of each type of participant represented. These limitations must be taken into account in data analysis but even with a small population size, there were still similarities present across participants.

As the first objective, the researcher wanted to determine if gender differences in science identity exist in this population. Among the limited group of participants the researcher surveyed, there was a not a large difference in science identity between males and females in the GLC certificate. However, the science identity of female participants was nearly 0.5 points lower, approximately 12.5% on the 4-point scale. Both males and females in the GLC certificate on average had a medium science identity. The average female science identity score was still in the medium range but was closer to the bottom of the range. Female scores were closer together than the male scores, but the average science identity score for both males and females was 3.50, slightly higher than neutral. Further data collection will allow for statistical significance testing and more confidence in apparent differences.

The second objective of this study involved determining the factors that develop one's science identity, especially in people who do not have STEM majors but pursue certification in this program that is heavily dependent on evaluating scientific solutions. The factors that influence science identity can be grouped into two categories: experiences and influences, with experiences being occurrences in someone's life while influences are pressures from people that alter their perceptions of science. Experiences include personal experiences, anecdotal experiences, and educational experiences. Experiences were found to both increase and decrease science identity, depending on if there was a positive or negative association felt towards science during the experience. Influences include parental influences, societal influences, and academic

influences. These influences have impacts on science identity that are similar to the experiences previously mentioned. This data was expected to impact science identity in this way. Similar results were found in the study of identity development through separate research by Bandura, Toren, Astell, and Wang and Degol. It can be concluded that their results on identity development and academic identity can be applied to science identity in an interdisciplinary context as well.

The final objective of this study was to determine how science identity plays a role in persistence throughout the program. It was found that science identity along with participant's views of science played a role in their participation and enjoyment in the program. Students had a wide range of science identity scores in the program, from 1.92 to 4.83, as well as a wide variety of majors. What made students persist in this program includes its interdisciplinary study and relevance. The Global Leadership and Change Certificate is interdisciplinary in that is intertwines applied science, social understanding, communication, and leadership to give students a well-rounded view on the complex issues our growing population is facing and potential methods to solve them. The GLC Certificate is also relevant to this diverse group of students both academically and personally. Whether they are learning how to better apply their major or learning skills and new ways to view situations, this certificate teaches students information that they view as being able to apply to the real world. These factors lead many students who by find out about this program by chance to complete this certificate. Focusing on these factors in the branding of the certificate program would allow better recruitment of students to the program.

Prior to the start of the study, objective 3 originally asked how one's science identity leads them to self-select into this program. After completion of the study, it was determined that

by taking science identity scores after participants were already enrolled in GLC courses, the researcher was unable to determine how science identity influenced self-selection because their identity score may have changed throughout the program. To answer this, another study must be completed to examine science identity scores at the beginning of the program before taking any classes and after GLC courses have been taken. The data collected was better able to answer the altered research question.

Science vs. STEM

Based on the definitions of science provided, participants consider the S in STEM to be the more commonly thought of sciences such as biology and chemistry while they believe science is a process that involves questioning and problem solving. What makes this interesting is that the 'S' in STEM is science but these students do not think a subject they consider to be science is STEM. This differentiation between science and STEM should be further investigated to get a more nuanced definition of each. A potential research question includes asking about both the definition of STEM, science, and to elaborate on the 'S' in STEM. Understanding why participants will consider a field science but not STEM is valuable for promotion of STEM-related fields.

Intersection between science and communication

Global Leadership and Change certificate students understand and prioritize the importance of science communication and education to make scientific issues relevant to everyone. This was illustrated through what was coded as global relevance. Participants emphasized the necessity of having a humanitarian connection to science, especially when solving complex issues the world will be facing with a growing population. This poses follow-up questions regarding where these views came from so they can become widespread and help in

the recruitment of more people to this program. Understanding if participants believed this prior to enrolling in the GLC Certificate or after taking courses in the certificate would allow better recruitment strategies. Conducting interviews before enrollment and after with questions relevant to this topic would provide us with better insight.

In conclusion, the researcher used science identity development to examine these students. The researcher found no difference between science identity scores in males and females in the GLC Certificate program. Two themes were found to determine one's science identity. One of these themes includes experiences which can be personal, anecdotal, or educational. The other theme found was influences which can be parental influences or expectations, societal influences, and academic influences. The role science identity plays in persistence through the program was also determined. Two major themes were found: interdisciplinary study and relevance. Interdisciplinary study involves applied science, social understanding, and leadership. Relevance pertains to educational relevance, personal relevance, and global relevance. Overall, students in the GLC certificate program viewed science as a process rather than a subject and that anything can be classified as a science because of this definition. Science was viewed as necessary when solving complex issues associated with a growing population as long as communication was involved with it.

Based on these results, the researcher suggests that this framework be used and adapted to continue to monitor students in the program and others like it. Adapting the study to have participants complete the survey and interview before they begin learning material in the courses as well as having participants in the program complete the survey and interview will allow a wider range of results. Through this, future researchers can determine if the definition of science given by these students existed prior to the GLC certificate program, causing them to self-select

into it or if it was developed through the program. Through understanding the students, their interests, and motivations, researchers and those associated with this style of program will be able to better recruit students to this style of program and help to promote this program. Understanding this will also help in adapting course structure and content to the needs of the students as well as ultimately allowing us to address these complex problems the world will be facing with a population of ten billion people in the year 2050.

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Appendix

I. Interview Protocol

1. What type of hobbies or activities do you like to participate in (today)?
2. Can you remember back and describe what sort of hobbies or activities you participated in as a child (can be up thru and including high school years)?
3. What were your favorite subjects in middle and/or high school? What made you enjoy this /these subject(s)?
4. Please describe a favorite role model (real or fiction) or someone you admire. What makes you admire this person?

Now I want to ask you about your thoughts and feelings about science. I appreciate your honest answers, there is no right or wrong answer on how you view science.

5. How do you define science?
    a. 5a. Do you think that agriculture is a science or uses scientific processes? (If they have no answer, ask them how they define agriculture?)
    b. Do you think this is how most people define science?
6. Tell me how you felt about science as a child.
    a. Where did this view come from?
    b. Have you felt any pressures to feel a certain way about science?
7. As a child, can you remember ever receiving any messages about science that contributed to this viewpoint?
    c. 7a. From whom or where did you hear these messages?
8. What do your parent(s)/guardian(s) do for a living?

9. What role do you feel science plays in your life? [are there any other ways science plays a role] In your community? [are there any other ways science plays a role] In the world?
10. Have you taken any science courses at the University yet? How did you feel about these courses?

Now I am going to ask you about your involvement in the Global Leadership and Change Certificate.

11. How did you hear about this certificate?
12. What motivated you to begin taking GLC Certificate courses?
    a. **How did you get involved with the leadership minor?**
13. Have any of the certificate courses impacted your attitudes towards science or identity as a scientific person? If so, which ones?
14. What role, if any, does science have in solving the complex problems our world will be facing in the coming years?
15. Have you had any additional thoughts on your perspectives on science, etc.
16. Do you consider your major to be a STEM or STEM-related field of study?
17. Do you think your career path will be a STEM or STEM-related career?
18. How will this certificate impact your future career?
19. What is the most recent course you have taken in this certificate?
20. Do you plan on finishing the certificate?