Journal of Agricultural Education, 61(3), 214-232
https://doi.org/10.5032/jae.2020.03214

Fostering Identity Development in Teacher Preparation: Service-Learning's Role in Empowering Agricultural Education Majors to Teach STEM Concepts

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Abstract

Existing evidence has demonstrated that educators often lack the competencies required to address science, technology, engineering, and mathematics (STEM) related issues and problems when teaching. As such, a need existed to identify ways to help preservice students negotiate meaning, construct knowledge, and become empowered to facilitate the teaching and learning of STEM in agriculture – a concept known as STEM identity development. One method of instruction used to achieve such is service-learning (SL). This study's purpose, therefore, was to describe the role of SL in empowering agricultural education majors at North Carolina A&T State University to expand their STEM identity over one academic semester. Findings revealed that as the project progressed, students articulated their SL experiences helped them evolve in three dimensions: (1) competence, (2) performance, and (3) recognition. However, students' ability to construct a more mature STEM identity was also filtered their unique contextual lenses as they engaged with racially diverse populations during the SL project. Moving forward, we recommend that teacher preparation programs more purposefully feature STEM-focused, SL experiences in teaching methods courses. Perhaps, such a curricular change could help better recognize, support, and leverage the identity trajectories of students while also ensuring that opportunities to feature STEM concepts in agricultural education continue to be expanded.

Keywords: diversity; identity development; service-learning; STEM education; teacher preparation; youth

Introduction and Literature Review

Teacher preparation programs occupy a complicated space in higher education in which they must attune their curricular and instructional strategies to align with current reform efforts, while also preparing graduates to succeed across diverse contexts (Schmidt & Datnow, 2005). For example, voices from business, education, and government have recently called for more emphasis on preparing individuals to teach science, technology, engineering, and mathematics (STEM) concepts (Alberts, 2013; Bybee, 2010; Kuenzi, 2008; National Research Council, 2011). These calls are the result of decades of evidence that has demonstrated that students are failing concerning STEM competency achievement (National Center for Education Statistics, 2018). And as a result, graduates are not prepared to solve the world's complex problems (Dauer & Forbes, 2016; Mentkowsi et al., 2000).

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Further, critics of education are concerned that the U.S.'s economic advantage might dissolve if interest and skill development in STEM remains neglected (President's Council of Advisors on Science & Technology Strategy to Improve STEM Education [PCAST], 2012).

Preparing teachers to meet such demands, however, would require them to navigate complex conceptual and practical issues. For example, existing evidence has demonstrated that secondary educators often do not possess the STEM-related knowledge and skills needed to address real-world problems in their classrooms (Bybee, 2010; Feinstein, 2011). This issue is further compounded by Pell's and Jarvis' (2001) finding that secondary students' interest in learning STEM concepts declined as they increased in grade level. As a result of such complexities, the adoption and implementation of STEM education strategies have primarily been stymied in U.S. classrooms (PCAST, 2012). To address this issue, Leggett-Robinson et al. (2018) argued that more emphasis should be placed on understanding how educators' understanding of STEM education may shape their ability to facilitate student learning. For example, teachers' personal views of their *competence* and *ability* often serve as a basis for their STEM identity – a construct that has been shown to influence students' achievement on multiple learning outcomes (Leggett-Robinson et al., 2018). As a consequence, understanding how identity formation occurs is critical to teacher preparation programs so they can more systematically facilitate this process for preservice students. However, scholars and researchers have struggled to explain how such manifests in practice (Polman & Miller, 2010).

Despite this lack of understanding, STEM identity development has been operationalized in the literature as the evolution that an individual undergoes as they negotiate meaning and become empowered to facilitate the teaching and learning of STEM concepts (Herrera et al., 2012). A more mature identity has been reported to improve educators' self-efficacy, competence, and motivation to deliver STEM-related instruction (Herrera et al., 2012; Legett-Robinson et al., 2018). However, it should be noted that an individual's STEM identity can be influenced by numerous contextual variables such as race, gender, and socioeconomic status (Good, 2012). As such, STEM identities can shift subconsciously, through deliberate action, or by exposure to a combination of unique contextual factors (Good, 2012). As an illustration, educators who deliberately addressed local issues and problems through their curriculum using a service-learning (SL) approach reported a more developed perspective on strategies they could use to facilitate the acquisition of students' STEM-related knowledge and skills (Herrera et al., 2012). Therefore, the combination of deliberate pedagogical interventions and contextual influences have been shown to help expand educators' STEM identity (Herrera et al., 2012; Leggett-Robinson et al., 2018).

Identity development is also of central importance to understanding how school-based, agricultural education (SBAE) teachers mature professionally (Roberts et al., 2016; Roberts & Montgomery, 2017; Shoulders & Myers, 2011). For example, Shoulders and Myers (2011) argued that the career demands placed on SBAE instructors required them to hold a distinct professional identity. Perhaps, this distinctiveness is the result of a need for SBAE instructors to exhibit a variety of characteristics to be considered effective (Jenkins III & Kitchel, 2010; Roberts & Dyer, 2004). To complicate this notion further, however, Swafford (2018) reported that teacher educators believed that more emphasis should be placed on preparing graduates to facilitate STEM-related teaching and learning in SBAE. Teacher preparation programs of agricultural education should, therefore, consider ways to encourage and support preservice students as they gain competence and form a more mature STEM identity. To this point, Smith et al. (2015) called for more effort to understand the instructional methods that empower students to achieve STEM competencies.

One method of instruction used to achieve such outcomes is SL (Newman et al., 2016; Wilson et al., 2015). Bringle and Hatcher (1995) defined SL as an opportunity to blend academic learning, meaningful service, and reflection through well-planned educational opportunities that allow students to solve local issues and problems. In the context of teacher preparation, SL differs from other preclinical experiences and internships because students not only acquire professional growth through leading instructional-based initiatives, but they also *address local educational problems and areas of need* (Cone, 2009; Lavery & Coffey, 2016). For example, some teacher preparation programs have used SL to help improve preservice students' self-efficacy and capability to facilitate the teaching and learning of STEM concepts by partnering with underserved racial and ethnic groups who are disproportionality marginalized in regard to their knowledge, resources, and career advancement in STEM (Borgerding & Caniglia, 2009; Jia et al., 2018; Wilson et al., 2015). Given such possibilities, the merger of SL and STEM education appears to promote the acquisition of critical outcomes for teacher preparation programs, resource-poor populations, and struggling communities (Newman et al., 2016; Wilson et al., 2015).

To this point, SL's use in teacher preparation has been shown to improve preservice students' competencies on several STEM-related outcomes (Borgerding & Caniglia, 2009; Cone, 2009; Wilson et al., 2015). For instance, Borgerding and Caniglia (2009) investigated the impact of a SL project on preservice students through an assignment in which they collaborated with underrepresented populations over three years to help service recipients better understand mathematics and use their knowledge to address community-based issues. Findings suggested the preservice students perceived that after their SL experience, they were more confident and prepared to teach mathematics as well as work in high-need contexts (Borgerding & Caniglia, 2009). Jia et al. (2018) also reported the method enhanced preservice students' (a) motivation, (b) understanding of STEM integration, and (c) identification of appropriate resources to address technology issues and problems in educational contexts. Because of such findings, SL appears to be uniquely positioned to help foster preservice students' STEM identity.

However, challenges to the method's use exist in agricultural education (Roberts & Edwards, 2015, 2018, 2020; Roberts et al., 2016; 2019a, 2019b, 2019c, 2020). For example, Roberts et al. (2019a) reported teacher educators' intentions to feature SL in teaching methods courses were practically nonexistent. Therefore, preservice students in agricultural education gain little exposure to the method before entering the classroom as in-service teachers (Roberts et al., 2019a, 2019b, 2019c). As such, Roberts & Edwards (2020) suggested that additional work be undertaken to demonstrate effective SL strategies in teacher preparation that promote positive outcomes for students and communities. Consequently, a need emerged to examine SL's role in empowering agricultural education majors to expand their STEM identity.

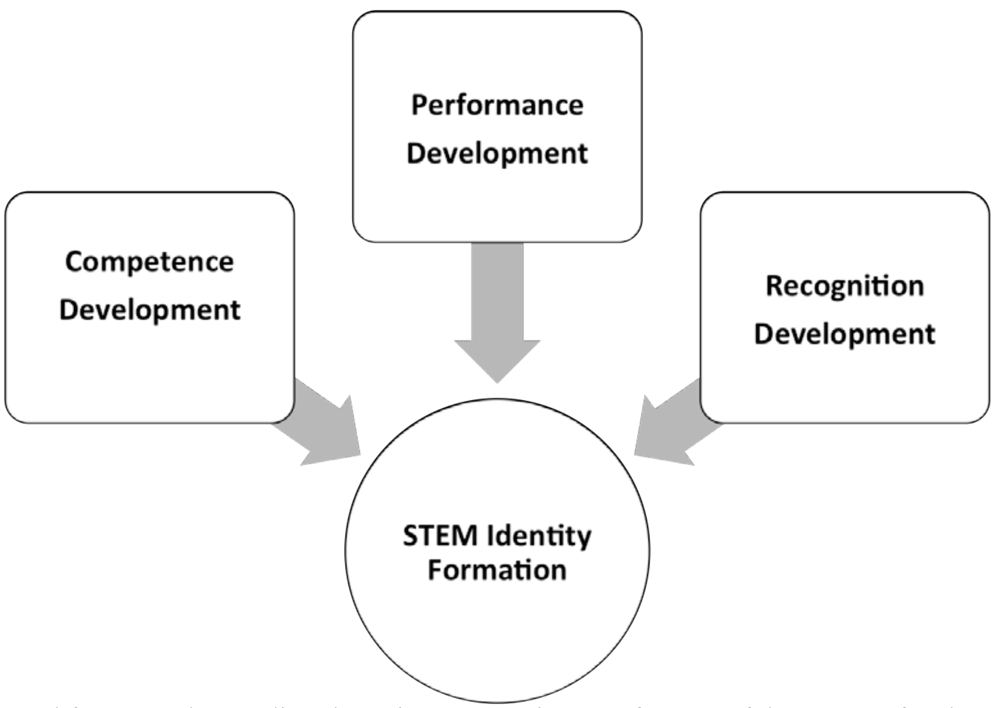
Emergent Theoretical Framework

Understanding how individuals construct a STEM identity through SL projects is a complex phenomenon (Polman & Miller, 2010). For example, previous research on identity development in the SL literature explained the phenomenon "as a process of struggle, negotiation, and meaning-making" (Jones et al., 2005, p. 7). Given the intricacy of identity development, we engaged in multiple rounds of data analysis and negotiations. As a result, we chose to ground this investigation *a posteriori* in Carlone's and Johnson's (2007) model of science identity (MSI). Carlone and Johnson (2007) explained that a plethora of forces, events, and circumstances influence an individual's identity. As such, identity development has been defined as the ability of an individual to make sense of their perceptions, knowledge, and skills to operationalize a distinct identity during periods of pivotal growth. These intrapersonal shifts represent the developmental stages that individuals experience as they question their previously assigned identity and construct a more mature perspective of themselves as a result of their lived experiences. At the core of work on identity, formation is an explanation of the evolution that occurs as individuals develop the skills they need to think contextually and become empowered to confront the STEM-related issues and problems they may encounter when teaching (Carlone &

Johnson, 2007).

Such an understanding of identity development led to Carolne and Johnson's (2007) work on the MSI, which was initially created to describe the experiences of women of color (Carolone & Johnson, 2007). Since then, scholars have expanded the model's dimensions by arguing that, despite an individual's race or gender, it could be used as an analytic lens (Herrera et al., 2012; Hughes et al., 2013). Other advancements to the MSI have suggested that the model should not be limited to *science* but could also be used to analyze individuals' evolution regarding *technology*, *engineering*, and *mathematics*, i.e., their STEM identity (Herrera et al., 2012; Hughes et al., 2013). When viewing identity development through the lens of the MSI, Carlone & Johnson (2007) theorized the process transpired as individuals matured in three primary dimensions: (1) competence, (2) performance, and (3) recognition (see Figure 1). The first dimension, competence, refers to the changes that occur as an individual expands their knowledge and understanding (Carlone & Johnson, 2007). Meanwhile, performance represents the developmental shifts as an individual learns to fulfill societal expectations when engaging with others, especially regarding how they *talk* and use *tools and equipment* to uphold STEM-related norms. The final dimension, recognition, reflects the intrapersonal evolution that occurs as one begins to view themselves as an individual with the knowledge and skills needed to deliver quality STEM instruction (Carlone & Johnson, 2007).

Figure 1
The Dimensions of STEM Identity Development



*Note.*Adapted from "Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytic Lens" by H. B. Carlone and A. Johnson, 2007, *Journal of Research in Science Teaching*, *44*(8), p. 1191.

Since its development, the MSI has helped advance thought on identity development (Herrera et al., 2012; Hughes et al., 2013). However, more work is needed to explain how individuals make meaning of their internal shifts as they form a more mature STEM identity during SL. In particular, additional evidence is required to illuminate the lived experiences that presage how students evolve throughout each dimension of the MSI. To better understand STEM identity development, we collected multiple forms of data to capture the shifts preservice students underwent as they engaged in SL over one academic semester.

Background of the Study – The SL Project

For this study, we investigated a SL project embedded in the *Methods and Materials of Teaching Agricultural and Extension Education* course at North Carolina A&T State University. The project's major activities occurred over a 14 week period. In its initial design, the project was conceptualized as SL rather than a traditional teaching internship because it allowed students to not only gain personal and professional growth but also *address an acute educational need in their community* – a core feature of SL in teacher preparation (Cone, 2009; Lavery & Coffey, 2016). In particular, students leveraged their pedagogical knowledge and skills to deliver STEM-based educational experiences aimed at building the capacity of audiences that traditionally lacked access to resources and quality information in agriculture, i.e., an *underrepresented population.* The project was also designed to provide the preservice students with the experiences needed to expand their STEM identity (Herrera et al., 2012).

To begin this process, 20 agricultural education students collaborated with organizations that included: (a) Black Farmer Clubs, (b) urban landscaping groups, (c) urban 4-H Clubs, (d) urban Girl Scout Clubs, and (e) more. Then, students individually conducted a needs assessment as well as systematic observations to identify STEM-related issues in agriculture that affected their selected organization. Through the needs assessment, students identified 20 target areas such as animal production, crop science, food science, horticulture, as well as others. Thereafter, students worked with leaders from their organization and the course's lead instructor to develop a plan to integrate STEM concepts effectively in lessons. Consequently, each student chose a different target area for the SL project and had distinct interactions with their organization. Nevertheless, a common thread wove them together – an emphasis on empowering underrepresented agricultural populations in STEM.

From the beginning stages of the SL project, students conceptualized their SL using an integrated STEM education approach in which they "explore[d] teaching and learning among any two or more of the STEM subjects. . ." (Sanders, 2009, p. 21). As a result, the lead instructor challenged students to design and deliver experiences that emphasized the integration of STEM in their selected target area. As an illustration, Participant #14 provided educational experiences to an urban landscaping group by integrating science, mathematics, as well as technology concepts to help the service recipients understand how to improve their horticultural enterprise. In total, students reported they built the STEM capacity of more than 200 individuals representing underrepresented populations in their local community. It should be noted that students were required to submit written reflections and photos to help them make connections between their coursework, the SL project, as well as how their STEM identity expanded. Then, at the project's conclusion, students shared their takeaways with their peers through a final reflection, which helped them understand how their SL experience made a difference for their selected racially underrepresented organization as well as themselves (see Table 1).

Table 1
Overview of the SL Project's Major Activities

Week(s)	SL Project Activities
1 – 2	• Students (N =20) individually selected an organization serving an underrepresented population.
3 – 4	• Students conducted a needs assessment of their selected organization. • Students conducted a minimum of five (5) hours of observation with their underrepresented organization. • Each student identified an agricultural target area for the SL project.
5 – 7	• Students developed materials and planned for the SL project, i.e., the 20 students designed educational experiences for their organization. • Students and the lead instructor coordinated to enhance educational materials. • Students submitted one (1) weekly written reflection.
8 – 12	• Students delivered four (4) integrated STEM educational experiences to their organization. • Students submitted one (1) weekly written reflection and four (4) photos with captions.
13	• Students submitted all final project materials.
14	• Students engaged in a final peer discussion and reflection in which they shared key photos and takeaways from their experience. Emphasis was placed on how their service impacted underrepresented groups as well as how their STEM identity evolved throughout the project.

Because of the SL project's design, we were uniquely positioned to view the shifts and changes that students experienced as their STEM identity evolved over one academic semester. A need emerged to explore the complexities of these changes further. This deficiency in knowledge led to the purpose of the current study.

Statement of Purpose and Guiding Research Question

The purpose of this investigation was to describe the role of SL in empowering agricultural education majors at North Carolina A&T State University to expand their STEM identity over one academic semester. To achieve this purpose, one research question guided the study: What changes did students undergo as they developed a more mature STEM identity during a SL project*?* Because this investigation promoted the building of capacity for students and underrepresented populations in a local context, it addressed the American Association for Agricultural Education's Research Priority Area 6: *Vibrant, Resilient Communities* (Graham, Arnold, & Jayaratne, 2016). Next, we provide insight into the biases and experiences that influenced our decision-making throughout this study.

Reflexivity

To own our biases in this investigation (Patton, 2002), we constructed the following reflexivity statement. We hope that by revealing our previous experiences and assumptions about this study, it promotes greater sincerity and honesty (Lincoln & Guba, 1985). To begin, it is critical to reveal that the lead researcher served as the instructor of record for the course under investigation. Two other researchers, who are both faculty members at North Carolina A&T State University, assisted during the design of the course. Further, all three researchers are former school-based, agricultural education

(SBAE) instructors; therefore, we held biases regarding how students learn STEM concepts in the context of agriculture. It is also relevant to reveal the lead researcher had previous SL teaching experience and has conducted research on the method. Such biases encouraged him to use SL to investigate students' STEM identity development. These experiences and views had the potential to influence our interpretations of the data. As a result, we negotiated findings and strove to reduce possibilities of bias in our methodological decisions whenever possible.

Methodology

In this study's design, we grounded our decisions in the worldview of *constructionism* (Crotty, 1998) to ensure our purpose, methodology, and procedural decisions were philosophically aligned (Koro-Ljungberg et al., 2009). Through the lens of constructionism, knowledge is ". . . contingent upon human practices, being constructed in and out of interaction between human beings and the world, and developed and transmitted within an essentially social context" (Crotty, 1998, p. 42). As such, this epistemological lens influenced our decision to use Stake's (1995) instrumental case study approach grounded this study because it emphasizes the role of using interpretations to *construct* an understanding of a case.

For instance, instrumental case study research provides insight into a specific issue within a case to illuminate how such an issue affects a phenomenon within a bounded system (Stake, 1995). As a result, researchers can provide a rich, contextually situated explanation of the case (Creswell, 2013). In this investigation, the approach allowed us to examine one particular issue, i.e., how the STEM identity of agricultural education students at North Carolina A&T State University expanded during a semester-long, SL project. As such, we bounded the case by *time* (one academic semester) and *unit of analysis* (the course). Next, we provide more insight into the participants' characteristics as well as how data were collected and analyzed for this case study.

Participants and Data Sources

Participants (N = 20) in this investigation were agricultural education majors enrolled in the *Methods and Materials of Teaching Agricultural and Extension Education* course at North Carolina A&T State University. Of the students, 12 (60%) were African American, seven (35%) were white, and one (5%) identified as other. Further, 70% (f = 14) of the students identified as female. Finally, 85% (f =17) of students reported they had a low socioeconomic status. In this study, the lead researcher engaged in all of the study's major activities throughout the 14-week project. Because of this experience, he was able to gain an *insider's view* (Saldaña, 2016) by interacting in-depth with participants by conducting regular observations of the day-to-day activities of the SL project. He was also able to gain insight into participants' successes and struggles as they engaged underrepresented populations in STEM concepts. Because of his position, he was able to collect a range of sources to gain a *rounded view* (Patton, 2002) of how students' STEM identity expanded during the SL project.

To triangulate findings from this investigation, we collected the following data sources: (a) interviews, (b) participant developed documents and materials, (c) written reflections, (d) participant submitted photographs, and (e) observation/field notes. Besides assuming the role as a *participant observer* (Patton, 2002), the lead researcher also conducted semi-structured interviews with each participant (N = 20) at the conclusion of their SL experience, which lasted from 60 to 85 minutes in length. He also conducted follow-up interviews to allow the students to extend or clarify their thoughts and views. After the lead researcher transcribed each interview verbatim, the participants were asked to review the transcripts for accuracy, i.e., *member checking* (Creswell, 2013). To facilitate systematic observations, we used Emerson et al. (2011) procedures to capture meaning through jottings and field notes. To further triangulate findings, we also collected *documents* (Linde, 2009) and *visual evidence*

(Pink, 2007) to achieve *saturation* of the study's findings.

Data Analysis

In our analysis of the data, we grounded our procedures in Corbin's and Strauss' (2015) constant comparative method. To accomplish this, we used *incubation* and *immersion* (Patton, 2002) techniques to code, reduce the data, and arrive at themes. This process was facilitated by three coding levels: (1) open, (2) axial, and (3) selective (Corbin & Strauss, 2015). To initiate open coding, we read each source of data line-by-line (Corbin & Strauss, 2015) and then analyzed sources through different lenses using Saldaña's (2016) *in vivo*, *descriptive*, and *process* coding procedures. Through this approach, we were able to produce 1,154 open codes that preserved *context* and *meaning* (Corbin & Strauss, 2015). In our second level of analysis, *axial coding*, the researchers entered a phase of negotiation as we analyzed the existing relationships among the initial codes – a technique advanced by Saldaña's (2016) to achieve inter-coder agreement. Through this process, we collapsed the open codes into eight broad categories (Corbin & Strauss, 2015). To maintain context, we then employed horizontal analysis to compare the axial codes with our field notes. Thereafter, we merged *indigenous concepts* (Emerson et al., 2011) with the axial codes through a conceptual memoing technique (Saldaña, 2016). Our final cycle of analysis began by developing *evidentiary warrants* that aligned participants' words with our preliminary meta-inferences of the study – a process illuminating the data's existing *congruencies* and *discrepancies*.

To substantiate our evidentiary warrants, we began to "think with theory" (Jackson & Mazzei, 2012, p. 6) through a plethora of different frameworks. Through this *alternative read* of the data, we noted that several of our categories could be interpreted through Carlone's and Johnson's (2007) MSI because it helped explain participants' maturation regarding their STEM identity. However, we also noted that discrepant categories appeared to reflect critical *contextual factors* that shaped students' development. As a result, we engaged in a final round of *selective coding* in tandem with analytic memoing (Saldaña, 2016) to reveal the changes students underwent during the SL project. When viewing the data in this way, themes emerged. We interpreted the themes as the processes that students' underwent as they expanded their STEM identity using Carlone's and Johnson's (2007) MSI. To provide more insight into how we upheld rigor and trustworthiness as we collected and made meaning of the data throughout this process, we next provide an overview of the strategies we used to achieve such.

Rigor and Trustworthiness

To ensure this investigation provided *quality conclusions* (Miles et al., 2014), we embedded Lincoln's and Guba's (1985) standards for rigor and trustworthiness – confirmability, dependability, credibility, and transferability – throughout each phase of this study. The standards severed as our primary anchor as we maneuvered through the various ethical-based decisions that arose in this investigation. For example, we upheld *confirmability*, or the ability to remain neutral and reasonably unbiased, in this investigation using three major strategies: (1) providing a clear explanation our data collection and analysis procedures, (2) being explicit about our values, worldviews, and biases, and (3) maintaining an audit trail. We also emphasized the importance of producing findings that are consistent and stable over, or *dependability*, by collecting data through a range of sources and negotiating interpretative differences among researchers. The third standard, *credibility*, refers to whether the findings make sense and ring true. To accomplish this, we provided context-rich descriptions and triangulated our findings through multiple data sources. Finally, *transferability* represents whether the findings of a study can be transferred to other contexts. In this study, we emphasized transferability using the following techniques: (1) providing participants' characteristics so that adequate comparisons could be made to other samples, and (2) providing a thick description of the findings. Using these strategies, we upheld standards rigor and trustworthiness as we interpreted the findings of this study.

Findings

Through our analysis, three themes emerged. The themes described the processes that agricultural education majors at North Carolina A&T State University underwent as they expanded their STEM identity during the SL project. To interpret our findings, we used Carlone's and Johnson's (2007) MSI as a lens to reveal the stages of participants' STEM identity development (see Table 2). Before offering our interpretation of the findings, it is critical to acknowledge that each dimension of STEM identity development – competence, performance, and recognition – identified in this investigation was heavily influenced by contextual factors. For example, the underrepresented groups that students interacted with, the lesson students designed and delivered, and the professionals they interacted with appeared to greatly shape the ways in which students began to make meaning of the STEM identity maturation they experienced. As such, contextual factors appeared to filter how students experienced the varying stages of STEM identity development.

Table 2
Students' Evolution throughout each STEM Identity Dimension During the SL Project

	Stages of STEM Identity Development		
Stage	Initial	Transitional	Mature
Competence	Students view knowledge in STEM as *right* or *wrong*. They are also resistant to accept STEM information that challenges their existing belief systems.	Students developed an evolving perspective of STEM. They also begin to see value in having students draw their own conclusions.	Students consciously shift their perspective and began to articulate the SL project helped them become more competent in teaching STEM concepts.
Performance	Students' communication about STEM is regulated by societal norms and they experience anxiety in regard to teaching STEM concepts.	Students communicate about STEM in ways that are distinct from the perspectives of others; they also begin to experiment and use technology to support their development.	Students learn how to mobilize resources in their context to better teach STEM concepts and facilitate inquiry-based instruction.
Recognition	Students do not recognize themselves as an individual with the capacity to teach STEM concepts. As such, they have little motivation, self-efficacy, of skills.	Students' begin to see value in STEM; however, gaining the approval of others primarily influences their motivation, self-efficacy, and skill development.	Students recognize themselves as individuals with the ability to teach STEM concepts. As such, they are largely intrinsically motivated, self-efficacious, and have appropriate STEM knowledge.

Stage #1: Competence Development

In the initial stages of the SL project, students viewed STEM concepts as set of facts that should be learned. Further, they also held the view that STEM concepts should be delivered using teacher-centered approaches. As a result, when teaching students about STEM, they held the view they should hold a position of authority by which they passively transferred knowledge to students rather than though active engagement in the knowledge construction process. For example, Participant #7 shared: "I am a bit concerned about teaching STEM lessons because I feel like I do have all of the concepts memorized that I need to pass on to students." Several of the students also shared that they viewed STEM knowledge as *right* or *wrong*. As an illustration, when describing his expectations of the project, Participant #18 explained, "I think I am going to focus on STEM facts by delivering a PowerPoint. STEM can just get too complex for kids. And I do not want to introduce topic that might be controversial."

As students' STEM identities began to transition, they began to adopt a more critical awareness of the importance of helping the individuals they were teaching to draw their own conclusions about STEM in agriculture. For instance, in students' reflections during Week #5, they highlighted the role that *observations* played in helping them understand the types of STEM knowledge and skills warranted by the group they intended to serve. Participant #16 clarified: "At first I thought the observations were pointless, but after I started talking to some of the Black Farmers Group members I started to understand the types of STEM knowledge they needed and began to understand the importance of providing inquiry based learning opportunities." Participant #20 also perceived she gained deeper understanding through her observations. She explained:

> The observation aspect was really important for me. I got to see how the girls interacted with each other. I also got to talk to them about their interests. Most of them [the girls] did not think STEM was very cool, so when I designed my seminars, I tried to make sure it was fun but also helped them think critically.

In the final stages of the SL project, students also noted they perceived they had gained competence in STEM. In particular, students reported they began to understand better the connections between STEM concepts and their coursework. Participant #9 shared:

> I had to take my Praxis exam [a requirement for teacher certification] a few weeks ago, and I noticed that some of the concepts that I was tested on were some of the same ones that I was teaching to the 4-H kids, it was really cool to see that connection and feel confident.

Participant #13 also perceived he developed more competence in STEM as a result of the SL project. He revealed: "Because of this experience, I feel a lot more confident in my ability to teach STEM. I think before I would have skipped over them [i.e., STEM topics], to be honest, but now I see that I can do it and that it [can be] fun."

Stage #2: Performance Development

The second theme, performance development, highlighted the processes students underwent to master their environment and learn how to better communicate about the role of STEM in agriculture. For instance, in the initial stages of SL project, we captured fieldnotes about how students reported feelings of *anxiety* and *stress* when attempting to understand and design curriculum on STEM topics. During individual interviews, we probed students on why they experienced such emotions. Participant #4 explained: "STEM just really stresses me out. I know its important and all, but it just makes me nervous." Participant #6 agreed, she expounded: "I mean I like STEM, but it can get really complex and stressful sometimes."

However, as the STEM identities began to transition, students began to navigate these insecurities productively through additional practice and working with STEM experts. Participant #12 explained: "Because I was nervous, I practiced and rehearsed the material quite a bit, which helped me feel more confident." However, Participant #19 used another approach; she revealed: "Because math is hard for [me], I got a lot of assistance from a professor in the math department. Just having her explain the concepts really helped me feel more confident."

In the final stages of the SL project, **s**tudents also learned how to recognize and use resources in their environments to teach STEM concepts. Such practices appeared to expand students' STEM identity by helping them gain confidence in their ability to facilitate student learning. Participant #15 shared: "During the project, I learned how important it was to use the local resources available. At my SL site, we had access to a few GPS systems, so I decided to flip my lesson around to highlight the use of technology in plant science. Being able to do this really helped me feel more confident."

Stage #3: Recognition Development

The final stage, recognition development, reflected the specific actions students took to expand their STEM identity during the SL project. As an illustration, in the beginning stages, we observed that students' motivation appeared to be more extrinsic. For example, they primarily inquired about the project's *requirements* and *grading policies*. As students took more ownership of their experience, their motivation appeared to shift. In particular, Participant #3 explained that she "got more motivated" as the project progressed. Participant #11 expressed similar sentiments when she wrote the following passage in a reflection: "When I first started the [SL] project, I was annoyed that it [would require] so much work. But after working with the Girl Scouts, I get a lot more passionate about STEM." Meanwhile, Participant #7 explained that his motivational shift occurred after interacting with a local Black Farmers Club. He shared: "When this [the SL project] first started I just wanted to get a good grade, but after I started teaching the farmer group about the science aspects of growing crops it felt good to see I was helping them and I got more motivated."

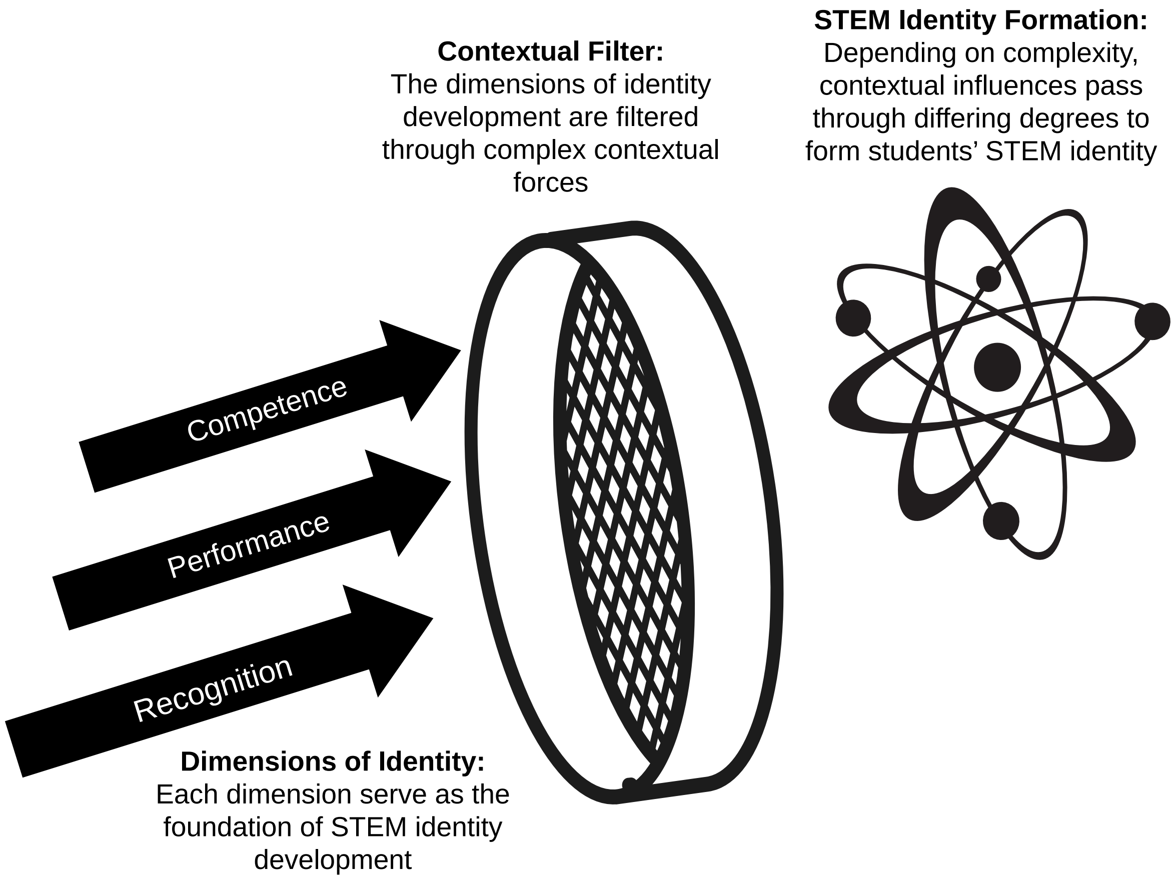
As students' identities began to transition they also began to articulate more self-efficacy in regard to teaching STEM concepts. For instance, emergent patterns from our fieldnotes demonstrated that students were initially *hesitant*. However, after analyzing participants' talk about their self-efficacy in STEM, we recognized this initial reluctance evolved throughout the project. For example, Participant #19 explained: "I was really nervous about the STEM aspect because I am not strong in those areas. But after getting more experience, I feel a lot more confident now." Participant #2 also touched on this issue in one of her written reflections: "STEM can be really intimidating. I mean I do not know what to do with all of the microscopes and numbers, but this project has been good for me because I have to boil it all down and explain it to the kids." In the final stages of the project, students also explained how they had developed the critical skills needed to facilitate STEM teaching and learning in various environments. As an illustration, Participant #9 shared: "I was nervous when I started, but by interacting with the 4-Hers and helping them gain STEM knowledge through my teaching – it just made me feel confident and successful." Participant #7 added: "I learned a lot of new skills in this [SL] project and feel a lot more prepared to teach other people about STEM in agriculture."

Conclusions

This study's purpose was to describe SL's role in empowering agricultural education majors at North Carolina A&T State University to expand their STEM identity. Using Carlone's and Johnson's

(2007) MSI as a lens, we described three dimensions of participants' STEM identity development – competence, performance, and recognition – that emerged as a result of engaging in SL. We concluded that students' empowerment through each dimension helped them construct a more mature STEM identity. However, it is important to acknowledge that each dimension of STEM identity development was filtered through contextual forces that students experienced as they interacted with racially diverse populations during their SL project (see Figure 2). To further situate this study's findings, we next provide conclusions for each dimension of the participants' STEM identity development.

Figure 2
Model of STEM Identity Formation



The first stage, competence development, revealed how participants perceived themselves in regard to STEM. For instance, through our analysis, we illuminated the processes students endured to gain mastery over their environment during the SL project, which promoted their competence for teaching STEM concepts. Through this investigation, we noted that students accomplished such by acquiring a *critical awareness* and *mobilizing resources* to teach STEM in the context of agriculture. It is important to note that for the SL project under investigation, students were required to conduct initial observations at their service site. It appears that during these observations, agricultural education students began to build relationships and gain a deeper understanding of the types of resources that would be available. We conclude, therefore, that the interactional dimension of students' development helped them gain a greater sense of *belonging* – a critical element of STEM identity (Cone, 2009; Cartwright & Smith, 2017; Leggett-Robinson et al., 2018; Wilson et al., 2015). Although such has been advanced as an essential dimension of preservice students' STEM identity, little evidence exists in this regard for literature on teacher preparation in agricultural education.

In the second stage, performance development, students learned to cope with their STEM anxiety and use the skills developed throughout the SL project to enact positive change. The literature on STEM (Ramirez et al., 2016) has explored the influence that anxiety has on students' performance. However, findings from this study provided new insights into the ways that agricultural education majors coped with this anxiety and, as a result, perceived they gained more mastery of STEM concepts (Zimmerman, 1995). As a consequence, we conclude that SL not only helped students to acquire critical pedagogical and content knowledge but also empowered them to author a distinct STEM identity.

The final stage, recognition development, articulated how students took actions to expand their STEM identity. For instance, many of the students began the SL project extrinsically *motivated*. However, throughout the semester, their motivation shifted as they began to perceive more value in their effort. Students also gained *self-efficacy* and *perceived competence* in STEM as the SL project progressed. We conclude that these intrapersonal shifts framed how students viewed and interpreted their experiences and provided a basis for their STEM identity development. In the literature, Roberts et al. (2016) reported the importance that motivation played in shaping students' SL experiences. However, scant evidence exists in agricultural education concerning how the development of *self-efficacy* and *perceived competence* affects the expansion of preservice students' STEM identity.

Discussion, Implications, and Recommendations

In recent decades, teacher preparation programs have been challenged to prepare their graduates to teach STEM concepts better (Alberts, 2013; Bybee, 2010; Kuenzi, 2008). To accomplish this, however, agricultural education majors must acquire more confidence, competence, and ability in real-world contexts. The development of these skills has been shown to help preservice students to manifest their STEM identity (Leggett-Robinson et al., 2018). Given this knowledge, SL has flourished a method of instruction calibrated to foster the acquisition of such outcomes (Newman et al., 2016; Wilson et al., 2015).

In the current investigation, we built on existing knowledge by describing SL's role in facilitating three stages that participants underwent as they perceived they had become more empowered and, as a result, began to self-author a more mature STEM identity (Zimmerman, 1995). Given the findings of this study, we recommend that teacher preparation programs of agricultural education begin to more purposefully feature SL in teaching methods courses to encourage the expansion of preservice students' STEM identities. Currently, few teacher preparation programs use or teach about SL (Roberts & Edwards, 2015, 2018, 2020; Roberts et al., 2019a, 2019b, 2019c). Therefore, by highlighting the method's potential to facilitate the teaching and learning of STEM in agriculture, perhaps preservice students can foster more meaningful, authentic experiences for their future students and also address areas of need in local communities (Roberts et al., 2016). Given SL's possibilities, professional development opportunities should also be provided for inservice teachers to help diffuse (Rogers, 2003) the method as a strategy for enhancing STEM instruction.

Future research is also needed to examine the dimensions – *recognition*, *performance*, and *competence* – of STEM identity development identified in this investigation. In particular, additional work should be conducted to examine whether the aforementioned dimensions are stable across student groups. For example, do they extend to secondary and middle school students when they engage in STEM-focused, SL experiences? If so, teacher preparation programs should more deeply ponder how to prepare preservice and inservice agricultural education teachers to address such outcomes (Roberts et al., 2020). In our analysis of data, it also became apparent that students' written reflections helped them process and make meaning of how their STEM identity expanded during the SL project. As such, we suggest that future research examine the types of reflection that most profoundly assist preservice students in realizing their STEM identities.

In this study, Carlone's and Johnson's (2007) MSI served as a theoretical lens to interpret the study's findings. We recommend that teacher educators consider each theory's features to more appropriately foster preservice students' STEM identities. It should be noted that Carlone's and Johnson's (2007) MSI has primarily been used in quantitive studies. And, despite its usefulness in this investigation, we recommend that more theory-building efforts be undertaken to expand its use as a qualitative lens. For example, so far, the theory has been used to describe three constructs of STEM identity formation. However, future work should more evocatively explore the *process of identity formation.* Describing this process could assist practicioners with understanding how to design experiences and interventions that promote the maturatation of preservice teachers' identity development.

As voices (National Research Council, 2011; Pierrakos, 2013) call for teacher preparation programs to make improvements in regard to preparing graduates to teach STEM concepts, this study provided a valuable learning experience to agricultural education students by which they also built capacity in their local community. Perhaps such efforts could also improve the recruitment and retention of students in colleges of agriculture (Alston et al., 2019, 2020). Despite the SL project's successes, however, it did require considerable *resources*, *time*, and *human capital*. Therefore, we recommend that practitioners dedicate the curricular space needed to coordinate efforts at various service sites as well as with the students and volunteers to ensure the project is implemented successfully.

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