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Becoming a Scientist: Using First-Year Undergraduate Science Courses to Promote Identification with Science Disciplines

Chloe Ruff
Gettysburg College

Brett D. Jones
Virginia Tech

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Abstract
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Keywords
domain identification, first-year, undergraduate, motivation, physics, biochemistry

Disciplines
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Becoming a Scientist: Using First-Year Undergraduate Science Courses to Promote Identification with Science Disciplines

Chloe Ruff[1] and Brett D. Jones[2]
[1]Education Department, Gettysburg College, Gettysburg, PA 17325, USA
[2]School of Education, Virginia Polytechnic and State University, Blacksburg, VA 24061, USA

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In this qualitative study, we examined how two professors (a physicist and biochemist) of first year college students perceived their students' development of identification in biochemistry or physics and how they actively supported this development. The professors described students who entered college with different levels of domain identification and different expectations for their college science experience depending upon whether they were in a biochemistry or physics major. Although neither professor was familiar with research related to the concept of domain identification, their beliefs about their students' identification and academic support strategies generally aligned with the Osborne and Jones (2011) model of academic identification.

INTRODUCTION

When students enter college with a pre-selected major, the initial major-related courses immerse them in academic and social experiences that may reinforce their beliefs about their prospective major or cause them to re-evaluate these beliefs (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008). The professors in these first year, major-related courses have the opportunity to support these students as they envision themselves within the domain of their major. Although the primary purpose of most introductory courses is often to build students' *knowledge* in their major domain (e.g., physics, biology, chemistry), professors can also use these courses to create learning environments that can develop students' *identification* with their prospective major. Understanding factors that influence students' identification with their major are especially important in science-related majors because there is a lack of graduates in those fields. Understanding why students choose to stay or leave their major during their first year may be helpful in providing implications that faculty and administrators can use to help retain students in these majors.

Domain identification describes "the degree to which an individual values a domain as an important part of the self" (Jones, Ruff, & Osborne, 2015, p. 333). Domain identification develops from an individual's educational and social experiences and influences later academic outcomes (Osborne & Jones, 2011). This construct focuses attention on the impact of the *value* that an individual holds for a domain on later academic, social, and emotional outcomes (Walker, Greene, & Mansell, 2006). Although domain identification is related to positive academic outcomes (Osborne, 1997; Osborne & Jones, 2011), only a few studies have examined how instructors perceive or support these concepts (e.g., Jones, Osborne, Paretti, & Matusovich, 2014; Kunter, Baumert, & Köller, 2007). In this study, we examined how professors of first year students perceived and supported the development of their students' identification with their prospective major.

THEORETICAL FRAMEWORK

Domain Identification

Domain identification is the *selective valuing* of a domain as important to the self-concept or self-esteem of an individual (Osborne & Jones, 2011). This definition is based in the symbolic interactionist conception of self-esteem, in which the feedback individuals receive from the environment (in terms of academic performance, among other things) is filtered through their perceptions of the outcomes and evaluation of the importance of the domain to their self-esteem (Osborne & Jones, 2011). Thus, individuals are affected more significantly by their level of performance in a domain that they value greatly than in a domain in which they place little value (Osborne, Walker, & Rausch, 2002).

Within academic settings, domain identification is related to a number of positive academic outcomes. At the high school level, identification with the academic domain is positively correlated with learning and performance goals, as well as with the intrinsic valuing of academics, perceived ability, self-regulation, and both deep and shallow cognitive processing and is negatively correlated with absenteeism and behavioral referrals (Osborne & Walker, 2006). At the college level, academic domain identification significantly predicted GPA after one semester and again after two years, even when controlling for sex, race, and self-esteem. In addition, students at different levels of academic standing had significantly different levels of identification with academics. A high level of identification with academics measured upon entering community college was related to positive academic outcomes such as achieving Dean's List or Honor's standing; whereas a low level of academic identification was related to withdrawal, academic dismissal, or academic probation (Osborne, 1997). The results of these studies highlight relationships that form the basis for the model of domain identification developed by Osborne and his colleagues (Osborne, 2004; Osborne & Jones, 2011), which shows the connections between domain identification, social and motivational background factors, and academic and behavioral outcomes.

Antecedents of domain identification. The model of domain identification developed by Osborne and his colleagues describes the process by which a set of social and academic background factors impact domain identification and related motivation constructs which, in turn, impact behavioral and academic outcomes. These background factors include group membership (e.g., gender, race, ethnicity, class); family, peer, and community environment; school climate; and both formal and informal educational experiences (see Osborne & Jones, 2011 for more information). In relation to the background educational experiences, Osborne and Jones (2011) explained how the instructional strategies specified in the MUSIC Model of Academic

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Motivation (i.e., eMpowerment, Usefulness, Success, Interest, and Caring; MUSIC is an acronym; Jones, 2009, 2015) can reinforce students' domain identification. Jones et al (2015) have documented this process more specifically within the domain of science by explaining that teachers can encourage students' development of domain identification by: *eMpowering* students by supporting their sense of control, helping students to understand the *Usefulness* of concepts to current and future goals, providing students with opportunities for *Success* in their learning environment, considering and supporting students' *Interests*, and showing students that the teacher and others in the learning environment *Care* for them both academically and personally. Jones et al. (2014) provided empirical evidence for these ideas by documenting that the MUSIC model components were significant predictors of first year engineering students' engineering identification.

Consequences of domain identification. Domain identification interacts with students' goals, beliefs, and self-schemas to affect their effort, persistence, and academic engagement and outcomes. Osborne and Jones (2011) hypothesized that, in general, higher identification with an academic domain is closely related to greater effort to succeed, persistence when faced with failure or frustration, and the goals, beliefs, and self-schemas that support academic success. Conversely, low domain identification is related to low effort in the domain, low persistence, and the lack of goals, beliefs, or self-schemas that support success.

Domain identification is likely cyclical (Osborne & Jones, 2011). Thus, although domain identification may be a stable concept, it is not static, and could be impacted by frequent positive or negative academic outcomes. For example, a student's identification with a domain may decrease if she begins to receive performance outcomes that do not reflect her perception of ability or if the climate of the domain begins to emphasize negative stereotypes. Alternatively, this model shows how shifts in school climate, instructional strategies, or other precursors may also work to increase students' domain identification.

Influence of Social Support in the Development of Domain Identification

The first year of college is a transition point for many students and provides a context for examining how domain identification develops or changes within the student and how identification can be supported in formal academic settings. Researchers of domain identification have noted the influence of others (e.g., teachers, parents, peers, mentors) on the development of the constructs (Osborne & Jones, 2011; Steele, 1997) and the role of teachers from the perspectives of students (Jones et al., 2014). However, only a few studies of domain identification (e.g., Morales, 2008) have examined how professors perceive their students' development of identification or the methods by which professors perceive identification to be developed. Developing a better understanding of professor perceptions may provide a stronger basis to develop interventions and instructional strategies related to the development of identification in the science domains.

Domain Identification and Science Identity

Researchers examining students' persistence in science have also used the framework of "science identity." Science identity is based in a situated learning framework in which students' beliefs, goals, and sense of themselves as a "science person" develops from their participation in various communities of practice (e.g., home, classroom, extracurricular; Aschbacher, Li, & Roth, 2010; Brickhouse, Lowery, & Schultz, 2000; Gee, 2000). Research on science identity is focused on the development of identity through the interplay between the individual and social support (or lack of support) from teachers, parents, counselors, and peers. Harzari, Sadler, and Sonnert (2013) examined how college students' participation in science-related communities of practice and perception of themselves as a "science person" influenced their future plans in science. The role of the participation within a scientific community of practice likely corresponds with the role of "group membership" (as described by Osborne and Jones, 2011) or "belonging" (Goodenow, 1993). In contrast, domain identification is focused on the interaction between students' evaluation of their performance in science and their perception of value for the science domain. However, both science identity and science identification can be influenced by the instruction provided by professors.

Research Questions

The overarching goal of this study was to examine how professors' beliefs and instructional strategies can affect students' identification with their prospective science major. The three specific research questions were as follows:

- RQ 1: How do professors of first year college students perceive their students' identification with their prospective science major?
- RQ 2: How do professors support first year students' identification with a prospective science major?

To answer the research questions, we collected data from university professors who taught first year students in biochemistry and physics.

METHODS

Research Design

This study was an exploratory qualitative examination of two professors' beliefs about their first year students' identification with their prospective science major and the instructional strategies these professors' used to support their students' development of identification with the major. We collected data through interviews with two professors who had designed and taught first year experience courses in either biochemistry or physics.

Participants

The two participating professors were purposefully sampled from the faculty at a large, public, U.S. university because they were teaching a "first year experience course" in a science field. Dr. B was a Caucasian, female professor of Biochemistry and Dr. P was a Caucasian, male professor of Physics. Both professors were full-time, tenured full professors who had developed, and were currently teaching, a first year experience course for students who had declared a major in either biochemistry or physics.

Course Descriptions

Many first year students participate in introductory courses designed to build their content knowledge within their prospective major; fewer first year students participate in courses specifically designed to help them develop both content knowledge and an understanding of what it means to *be a member* of their major discipline. This study focused on the latter and included one first year experience seminar in biochemistry and one in physics.

Approximately 150 incoming first year and transfer students were enrolled in the biochemistry course. The biochemistry course was a one-semester, one-credit hour, pass/fail course that was taught by Dr. B and a graduate teaching assistant. Class sessions included a set of large group lectures and small group discussion sessions led by undergraduate teaching assistants (peer mentors) who were junior or senior biochemistry majors.

Approximately 60 incoming first year and transfer students were enrolled in the physics seminar. The physics course was part of a two-semester series in which each course was three credit hours and students were graded on an A to F scale. Dr. P and a graduate teaching assistant taught both semesters; all class sessions included the whole group. Both the biochemistry and physics courses were part of a university-wide focus on strengthening students' first year experiences and had learning outcomes and objectives that focused on building students' problem solving, information literacy, and integration of learning within the discipline.

Data Collection and Analysis

We used in-depth individual interviews to assess the professors' perceptions of their students' identification with their major. Using in-depth individual interviews helped us to understand the individual professor's perspectives and generated rich descriptive data. Each professor was asked to participate in one 45 to 60 minute interview. We used a semi-structured interview guide to keep the interviews focused on the study constructs (see Appendix). Prior to the interview, the professors were asked to complete an informed consent form approved by the university's Institutional Review Board.

We transcribed the interviews and used a constant comparative method of data analysis (Charmaz, 2009). Our initial coding was both inductive and descriptive using line-by-line open coding to allow key concepts to emerge from the data (Charmaz, 2009; Patton, 2002). In the second iteration analysis, we continued the process of analysis by consolidating the initial codes into a set of focused codes. These focused codes provided an initial description of the categories and subcategories emerging from the data. In the third iteration of analysis, we used analytical memos to ground our categories and analysis back in the voices of the participants and returned to the interview transcripts to provide support for the categories we had developed through the coding process.

FINDINGS

Three themes emerged from the coding and analysis of the faculty interviews: Theme 1, *Building on Prior Experiences and Significant Others*; Theme 2, *Thinking Like a Scientist*; and Theme 3, *Making Connections*. The first theme describes the professors' views of their students' development of identification with their prospective major. The second theme describes how the professors explicitly teach knowledge and skills that students will need to be successful in their science major. The third theme encompasses the strategies that the professors use to encourage students to make connections to older students, faculty, and researchers within their major. We explore each theme in detail in the following sections.

Theme 1: Building on Prior Experiences and Significant Others

When asked to describe the reasons why students choose majors in their science discipline, both of the professors connected their students' selection of a biochemistry or physics major to the students' prior experiences in high school math and science classes. In each case, the faculty described students who chose to enter the major as first year students as "liking" and "doing well" in related high school courses (Dr. B, biochemistry) and suggested that their students' value for and beliefs about their major were drawn from these high school experiences. However, the professors' explanations differed from one another in the way they described their students' entering interest in and value for their science major.[i] Dr. B, the biochemistry professor, focused on students' pragmatic choices in relation to their major and the influence of advice from teachers, parents, and school counselors in students' selection of a biochemistry major. In contrast, Dr. P, the physics professor, focused on the specific characteristics that he felt were common among physics students. In each case, even when describing students' plans for the future, the professors connected their students' choices back to students' understanding of the field in high school.

Biochemistry student profile. Dr. B described three reasons why students choose to major in biochemistry: "they're good at chemistry," they view biochemistry as preparation for "medical school or other biomedical professions," or they are interested in and "like life sciences and they're not really certain how they ended up in biochemistry." Dr. B suggested that students are influenced in their choice of biochemistry by both their experiences in high school biology and chemistry and by the guidance of parents, teachers, and high school counselors. Professor B described students whose teachers introduced them to biochemistry because they "did well" in both biology and chemistry. Other students were guided toward biochemistry for more pragmatic reasons; she described students and parents who reported that the earning potential for biochemistry "is higher than biology." Also, she pointed out that high school counselors introduced some students to biochemistry as preparation for medical school entrance exams.

Dr. B described some students as not having a strong interest in the field of biochemistry or any level of identification with the field. These students, Dr. B noted, chose their major based on their plans for the future, "not what I am interested in, but what I want to be when I am finished." These students value biochemistry for a highly pragmatic reason as "training potential" for future schooling and careers. Although their value for biochemistry is based in their plans for the future, Dr. B suggested that students' understandings of the fundamental concepts of biochemistry are based in their high school coursework in biology and chemistry. Thus, students view biochemistry as the application of chemistry in the medical field or the study of the "chemical mechanisms of life."

Physics student profile. Dr. P described students who begin their physics major during their first year as students who "probably were interested in science or something technical like that most of their lives." These students "enjoyed math" as well as the sciences that they took in high school and were drawn to the more mathematical science subjects (e.g., physics, chemistry). Dr.

P described a set of students who are drawn to physics because they are "motivated by the curiosity." These students' curiosity to understand how the world works is a personal "itch to scratch" rather than an attempt to change the world or prepare for their future careers.

The value of physics to society, or even to themselves, is not a key reason for these students choosing physics, as Dr. P notes, "I don't know if they *think* [physics is] important. They may be thinking that this is a subject that they liked in high school" (his emphasis). The same high school courses that sparked students' enjoyment and curiosity also have shaped their understanding of the field. Dr. P explained that students initially view physics as the "hardest, most detailed [subject] … because many students think of it as memorizing formulas and they're all very detailed mathematical formulas" and view the application of physics as limited because "they're seeing only specific examples, specific cases, and so it doesn't apply to other things." Dr. P suggests that the focus on memorizing in their high school courses (and even in early college courses) reinforces the idea that physics has few applications outside of the classroom: "'What can I do with a physics degree?' is one of the things that they ask all the time."

Theme 2: Thinking like a Scientist

Both of the professors described developing and changing their first year experiences courses to help incoming students to develop a more sophisticated understanding of the field and to explicitly teach them critical thinking skills that were essential to the students' success in upper level undergraduate and graduate courses. The professors described their courses as areas where students could go beyond the basic facts they were learning in introductory physics, biology, or chemistry to develop a better understanding of how physicists or biochemists think about the world and approach problems. Thus, these courses both exposed students to new ways of thinking about what they were learning in the field (and potentially new areas of interest) and the professors began to address misconceptions they felt that incoming students had about physics and biochemistry.

Encouraging big picture understanding. In both biochemistry and physics, the professors integrated experiences into the courses to help students develop a "big picture" understanding of the field. These experiences tacitly or explicitly encouraged students to expand their understanding of the discipline, their role (or potential role) within the discipline, and their value for it. In biochemistry, Dr. B invited three professional biochemists to talk with the class and led the students on a tour of one of the biochemistry labs at the university. Dr. B described the guest speakers as helping to provide the big picture and enhancing "our understanding of the natural world versus the student-centric view of this as a training potential . . . they [students] may not see the big pictures being asked, they see more the products that are used by society." Thus, by having biochemists talk to students about their research, students were developing a better understanding of how questions are asked and studied in biochemistry.

Dr. P described the first year experience course as providing the opportunity to expose students to the wider culture of physics and to provide students with an understanding of how they fit within this larger understanding of the field. He reported that he encourages students to develop a broader understanding of physics by explicitly talking with students about the broad culture of physics. He also built time into the course to talk with students about their own plans, "it's the only course where they get to talk about what they are planning to do . . . this is a broader look at their lives and physics: how physics will fit into their lives or not or whatever." Dr. P explained that students have a basic idea of what physics is but often end up getting into the "deeper spots" before understanding the breadth of the field of physics and options that the students may have for research or careers.

Early experiences in domain thinking. Both professors described integrating the explicit teaching of critical thinking and problem solving skills that are specific to the domain into the first year experience course. The professors explained that these skills are important to the students' success in upper level courses and research within the discipline, but these skills are rarely included in the foundational physics, biology, or chemistry classes that are prerequisite courses within the majors. Both professors also described teaching critical thinking skills as one way of addressing the misconceptions that incoming first year students often have about the discipline.

Biochemistry. Dr. B described intentionally designing the biochemistry first year experience course to focus on critical thinking skills rather than facts or knowledge about the domain. She introduced critical thinking skills to students in this course through the process of reading scientific articles to uncover the purpose of the research and to find descriptions of the scientific data used in the research. Dr. B described learning to read and interpret scientific research as a process that begins in the first year and can continue into graduate school for many students.

Dr. B's goal for the first year students was to help them make a connection between scientific data and scientific claims in research publications. She explained that this goal supported the students' access to the scientific literature in the domain and challenged students' misconceptions about scientific research. Dr. B assigned students articles to read and had students find an article of their own choice; however, "the language is usually so well developed in the introduction and the background of the paper that they do struggle with it even if they choose really simple papers." Dr. B's intention is not for students to fully understand what they read, but to provide them with a first experience with the literature: "for me as an instructor, I understand you get your feet wet, then you get up to your knees, and then you get up to your waist and all of the sudden the water doesn't feel so cold anymore."

Dr. B also described introducing students to scientific literature and scientific data to begin to challenge her students' misconceptions about the role of the scientist. She described many students who enter college with the belief that "it is a scientist's job to figure out what all those facts mean and present in classes and that they [students] have no business trying to figure out if the conclusions follow from the data." She explained that the purpose of immersing first year students in research articles was one method the department was using to reduce the number of upper-level biochemistry students who struggled to understand and interpret scientific data.

Physics. Dr. P designed the first year experience course in physics with the intention of supporting students' problem solving abilities. In particular, the ability to "think flexibly" and confidently approach problems without clear solutions. He immersed students in problems without easy or obvious solutions from the beginning of the course using "Fermi problems." In this type of problem, students are given very little information and must use estimation, approximation, and even educated guesses rather than formulas to develop a possible solution. Dr. P explained that he used these at the beginning of the course to help students to develop the confidence to approach and work through difficult and unclear problems.

In addition to solving Fermi problems in class, Dr. P assigned his students a large group problem during their first semester. He explained that the assignment was prefaced with the explanation that he was giving them "a large problem to solve which doesn't have an answer at all" and then told the students that they had been asked to serve on a panel to help solve the global energy crisis. The students were then assigned to groups and charged with working together to propose and research one method of addressing the global energy crisis. Dr. P used this project to support the students' ability to approach the problem thinking flexibly, have the confidence to choose a possible solution, and then to use research and their understanding of physics to test the solution, "and even if that idea doesn't work out, it's not successful, they work it out and decide that it's not . . . that's okay. They've done something, that's what I want."

Dr. P also believed that he was addressing one of the main misconceptions that students have about physics by providing students with many opportunities to solve ill-structured problems: the belief that physics is "extremely authoritative." He explained that students have been taught that "F does equal MA" but as physics majors they need to understand that the equations they have learned do not work under all conditions: "We try to teach them that you have enough information to actually work something out yourself without having to be told how it should work."

Theme 3: Making Connections with Research and Researchers

Both professors emphasized the importance of the first year experience course as a method of helping students make connections with other students, faculty, and researchers in the discipline. They felt that first year students involved in the course had the opportunity to learn more about what it meant to be a student in the discipline and to learn about research within the discipline at the university.

Informal mentoring. The biochemistry and physics first year experience courses both included forms of informal mentoring of the incoming students. Both of the classes were too large for the professors to engage in a formal mentoring with all of the students; however, both of the professors were tenured professors who were engaged in both research and teaching in the field.

Dr. B shared teaching responsibilities for the biochemistry first year experience course with a set of undergraduate peer mentors. Dr. B taught half of the class sessions as a whole class lecture in a large lecture hall and peer mentors (junior- and senior-level biochemistry majors) facilitated half of the sessions as small group discussions. The peer mentors guided students through the process of completing their course-of-study planner in which the first year students mapped out the courses they planned to take during their years in college. The peer mentors also helped to guide the students through reading and talking about research articles. Dr. B described the peer mentors as "a good source of tips" for the incoming students.

Dr. P, in physics, explained that even though the size of the class prevented one-on-one mentoring with all incoming students, he focused on making personal connections with his students:

> I want to hear from them and I want to react to what they're talking about and I want them to react and tell me what they're doing. So yeah, the more I can make a personal connection the better…. You can't quite do one-on-one and mentor-mentee, but the more you get that feeling in the course the better.

Within the physics course, Dr. P encouraged students to talk about their future plans for college and post-college to help them move beyond viewing physics as a collection of assignments to a broader understanding of "how physics will fit into their life."

Access to research opportunities. Both the biochemistry and physics professor emphasized the importance of introducing their students to researchers and to possible undergraduate research opportunities at the university. In biochemistry, Dr. B included three activities intended to help students understand and access research at the university. Throughout the semester, three researchers visited the class to talk about their research with the students and discuss how their research fit into the field of biochemistry. Near the end of the semester, students participated in a laboratory tour, choosing one of the biochemistry labs on campus to visit with a small group of other students in the class. Dr. B also included one assignment in which students brought to class information about an undergraduate research opportunity of interest to them. Dr. B explained that increasing the number of first year students participating as undergraduate researchers was a positive, though unintended, consequence of this assignment.

In physics, Dr. P invited researchers from the physics department to discuss their research with the class during the second semester of the course. For Dr. P, the research talks served multiple purposes: (a) to expose students to areas of research within physics at the university in order to introduce students to topics for research they could be involved in as undergraduate or graduate students; (b) to encourage them to think about how they could use their physics degree, either in research or in other fields such as medicine or law; and finally, (c) to introduce students to "the community of the physics department" with the idea that students would be taking courses or researching with many of the researchers who spoke with the class.

DISCUSSION and IMPLICATIONS

To examine how professors' beliefs and instructional strategies can affect the development of students' identification with their prospective science major, we relate our findings to Osborne and Jones' (2011) model of domain identification.

Professors' Beliefs about Students' Identification

The professors did not talk about domain identification explicitly. For example, neither professor described their students as valuing the domain as an important part of themselves, nor did they describe students as defining or identifying themselves with their major. However, the professors' descriptions of their students and their descriptions of the activities that they integrated into the course do illustrate aspects of the antecedents of domain identification described in Osborne and Jones' (2011) model of domain identification. In particular, the professors' descriptions stress the importance of prior educational experiences and significant others in developing students' domain identification.

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In Theme 1, the professors described students who are entering their prospective majors with two different levels of experience in the disciplines. In biochemistry, Dr. B described students who were entering a new domain; they may have had a strong background in science, biology, or chemistry, but had not participated in educational experiences related to biochemistry. In contrast, the physics students that Dr. P described had a large set of experience in physics related to their high school coursework and likely had developed some level of identification with physics; however, their experiences were within the context of high school physics. We propose that the students' levels of experience in the programs shaped the context of their domain identification. Dr. B worked with students who were entering a new domain; and thus, although they may have had a strong identification with science, biology, or chemistry, they had not yet developed a biochemistry identification. In contrast, Dr. P supported students' physics identification by helping students' transition from their identification with high school physics to their identification with undergraduate and upper-level physics. Regardless of students' level of identification, we believe that professors could use the MUSIC model to help foster students' domain identification, as discussed in the next section.

Supporting Identification through Course Design

The strategies that professors can use to promote students' domain identification include those that are consistent with the MUSIC model (Jones, 2009, 2015), as discussed previously, such as: empowering students by allowing them to make decisions within their learning environment, ensuring that students understand the usefulness of what they're learning, helping students to believe that they can succeed in the course activities, interesting students in the course activities, and demonstrating that they care about their students' success in the course (Jones et al., 2014; Jones et al., 2015). We found that the professors were using all of these strategies, indicating that their instructional strategies are consistent with those that can be used to support the development of students' domain identification. In this section, we provide examples from our findings to demonstrate how the professors incorporated strategies consistent with the MUSIC model into their instruction. The instructional strategies used by Dr. B and Dr. P often provided support for more than one of the MUSIC model components (see Table 1). For example, taking a tour of a biochemistry lab could help students understand the relevance of biochemical research to their personal goals and be an enjoyable experience that triggers an interest in a specific area of research.

Both professors empowered students by giving them some level of choice and control within the course activities by assigning activities that had multiple solution paths and assignments that encouraged students to choose from a selection of the articles to read or labs to visit. For example, Dr. P required students to complete a large-scale group project about an energy crisis, which allowed them to consider many different possible solutions.

The professors also demonstrated the usefulness of the content by actively encouraging students to understand how the domain was connected to their short- and long-term goals. For instance, Dr. B invited guest speakers to help students understand the purposes of biochemistry and Dr. P invited researchers from the physics department to discuss their research and introduce students to undergraduate research opportunities. These types of experiences can help students learn more about the role of the scientist in their discipline and help them to refine their short and long terms goals related to the discipline.

The professors incorporated several instructional design features that could help to foster students' perceptions of success. First, the professors structured their courses to help students develop the skills they would need to be successful in upper-level courses within the major, including challenging students' misconceptions about the discipline through lecture and class discussion. They also provided students with scaffolded opportunities to develop skills such as flexible problem solving, reading scientific research, and interpreting scientific data.

The professors also integrated activities that were designed to trigger students' interest. Dr. B took students on a tour of the biochemistry lab, which was likely interesting and enjoyable for students. Dr. P's choice of topics for class and group projects may have sparked student interest through novelty or relevance to scientific research in global energy consumption. Both professors developed courses that could provide students with a positive, enjoyable first college experience within the discipline. The professors developed these courses based on their understanding of topics that students in the discipline found interesting or intriguing. They also included activities designed to connect with a variety of individual student interests by providing students with the flexibility to choose topics for group research and to visit different types of biochemistry labs.

Finally, the professors showed that they cared about students' learning and success in the courses through direct interactions, as well as by establishing opportunities for students to feel supported by other students. For example, Dr. P engaged with individual students and small groups during in-class group-work sessions to create a more personal learning space within a large class. Dr. B set up times for small group discussions that were led by upper-class biochemistry majors and allowed peer mentors to lead small discussion groups in which they provided tips and answered questions about biochemistry courses. Of course, just because students work together or engage in discussion does not mean that they feel cared for. In fact, the opposite can occur if students feel disrespected or are treated unfairly by other students. Therefore, it is critical that professors ensure that students know how to work productively together in a supportive manner.

LIMITATIONS AND FUTURE DIRECTIONS

The findings of our study must be interpreted within the context of the limitations. One limitation is that we reported the professors' perceptions of what they do in their courses. Their perceptions may not have been completely accurate for a variety of reasons, including that they may have misremembered or misinterpreted some things that happened. For these reasons, it can be helpful to interview or survey students about their perceptions of the course or to directly observe the instruction during the course. In a related qualitative study of students participating in these two courses (Ruff, 2016), students reported similar perceptions of these courses. The students connected their current interest in the discipline with prior science experiences and they evaluated their major in relation to current long-term goals and aspirations. They described their willingness to engage in activities that they deemed "important, but not interesting" if they perceived the activity as relevant to their future goals in the domain. The students were less likely to see activities as useful to current goals if the instructional strategies in the first year experience course did not match instructional methods in the introductory foundational physics or chemistry courses they were taking concurrently. Students' difficulty in understanding the usefulness highlights the challenge of providing a first year experience that is not coupled with the introductory courses for the major.

In the future, it could be useful to design experiments that allow the researcher to compare the impact of various instructional strategies on students' domain identification. For example, does an open-ended problem-based learning experience designed to empower students actually do so compared to a more traditional lecture-style course? It could also be useful to assess students' levels of domain identification over time to examine its rate of development. It is possible that if students' domain identification does not increase, that students will change majors; however, more research is needed to explore this possibility.

SUMMARY AND CONCLUSIONS

Professors in the biochemistry and physics courses perceived their students' identification with their prospective major somewhat differently. The biochemistry professor described students who had an interest in biochemistry, but generally low identification with the domain of biochemistry because of their lack of experience with biochemistry. The physics professor described students who had an emerging identification with physics that had been developed through their high school science experiences. Therefore, although there are similarities in the strategies these professors can use to foster students' identification, the differences in students' levels of identification may need to be considered. Future research could examine whether some of the MUSIC model components are more important than others to students at different levels of domain identification.

Neither professor was familiar with the academic research in the field of domain identification; however, both used instructional strategies consistent with the MUSIC model (even though they did so unknowingly) that supported students' identification with their major. It is possible that with an understanding of domain identification theories and the MUSIC model, professors could more intentionally design instruction to develop students' identification with their major. Professors could obtain this knowledge rather quickly by reading sources such as Jones (2009, 2015) or visiting the MUSIC model website (www.theMUSICmodel.com). Armed with these basic strategies, professors could use their creativity and experience to design learning experiences that engage students and foster their domain identification. Future research could examine whether more intentionally implementing MUSIC model teaching strategies could increase students' levels of identification as predicted (Osborne & Jones, 2011; Jones et al., 2014; Jones et al., 2015).

As important as it may be to increase students' levels of domain identification, we believe that it is more important for students to have the information needed to accurately assess their level of identification with a domain. Future research could examine whether some teaching strategies are more critical than others in helping students understand what it means to be a professional in the field and whether they fit within that field. With accurate perceptions of the possibilities within a field, students can make better decisions about their career paths.

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APPENDIX

Faculty Interview Guide

1. What are some reasons that you feel students choose to enter this university as a biochemistry/physics major?
2. Who or what do you feel influences your students' decision to choose this major?

Listing Activity:

3. On this half sheet of paper would you list or describe:
   - How would your students describe the field of biochemistry/physics?
   - What do your students think are the key aspects of biochemistry/physics?
   - How do your students feel that biochemistry/physics is important (to themselves and to society)?
4. Now I would like for you to flip the paper over and list or describe:
   - How do you describe the field of biochemistry/physics?
   - What are the key aspects of biochemistry/physics in your view?
   - How do you feel that biochemistry/physics is important (to you as an individual and to society)?

Now unfold the paper so that the two lists are both visible.

5. Of the lists you have here, what do you feel are the greatest areas of difference between how you and how your students view biochemistry/physics?
6. What do you feel are the greatest misconceptions that students have related to their beliefs about biochemistry/physics?
7. Now I would like for you to think about the different aspects of your biochemistry/physics first year experience seminar. Which aspects of the seminar do you feel help to address the differences between your view of biochemistry/physics and your students view?
8. What choices do students have in how they participate or complete activities or assignments during the course?
9. How useful or important is the seminar to students' lives, either now or in the future?
10. With which aspects of the course were students successful? Which aspects did they find difficult?
11. What did students seem to find most interesting and enjoyable about the course? What did students find least interesting and least enjoyable about the course?
12. How did you show students that you cared about their academic success?
13. How much effort did students put into the course?
14. Which parts of the course do you feel are the most necessary for your students to be successful biochemists/physicists?
15. Finally, coming back to students' beliefs about biochemistry/physics, what do you feel is the main way that students change how they view biochemistry/physics over the course of the seminar?

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[i] In these interviews, the professors were asked about their students' value for the domain rather than their level of domain identification to focus on the components of domain identification and prevent misunderstanding.

TABLE 1. Instructional Strategies Associated with Themes 2 and 3

Instructional Strategies	**MUSIC Model Components**				
Theme 2: Thinking Like a Scientist	*eMpowerment*	*Usefulness*	*Success*	*Interest*	*Caring*
Biochemistry					
Connected activities to students' long-term goals.		X			
Took a tour of a biochemistry lab.		X		X	
Required students to find and read scientific research.		X	X	X	
Challenged students' beliefs about the authority of the scientist.		X			
Included guest speakers and a lab tour to help students understand the purposes of biochemistry.		X		X	
Physics					
Focused on problems with multiple solutions and multiple paths to a solution.	X				
Provided ill-structured problems to challenge students' understanding of problem solving in physics.	X		X	X	
Provided multiple opportunities to practice flexible problem solving skills.			X		
Required a large-scale group project about an energy crisis to challenge students to work together to develop solutions.	X		X		X
Taught flexible problem solving to support success in higher level physics courses.			X		
Provided support for beginning and solving complex problems.			X		
Structured activities and discussions to challenge students' beliefs about physics and physicists.		X			
Theme 3: Making Connections	*eMpowerment*	*Usefulness*	*Success*	*Interest*	*Caring*
Biochemistry					
Used a course-of-study planner to connect the biochemistry major to students' long-term goals.		X			
Invited guest speakers to discuss the practical contributions of their own research.		X			
Set-up small group discussions led by upper-class biochemistry majors.			X	X	X
Allowed peer mentors to lead small discussion groups giving tips and answering questions about biochemistry courses.			X	X	X
Physics					
Encouraged students to make connections between physics and their long-term goals.		X			
Invited researchers from the physics department to discuss their research and introduce students to undergraduate research opportunities.		X			
Engaged with individual students and small groups during in-class group-work sessions to create a more personal learning space within a large class.					X