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Fostering Students' Identification with Mathematics and Science

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Fostering Students' Identification with Mathematics and Science

Abstract

Book Summary: *Interest in Mathematics and Science Learning* is the first volume to assemble findings on the role of interest in mathematics and science learning. As the contributors illuminate across the volume's 22 chapters, interest provides a critical bridge between cognition and affect in learning and development. This volume will be useful to educators, researchers, and policy makers, especially those whose focus is mathematics, science, and technology education.

Chapter Summary: The primary purpose of this chapter is to explore the process whereby students transition from a short-term, situational interest in mathematics or science to a more enduring individual interest in which they incorporate performance in mathematics or science into their self-definitions (e.g. "I am a scientist"). We do so by examining the research related to domain identification, which is the extent to which students define themselves through a role or performance in a domain, such as mathematics or science. Understanding the process of domain identification is important because it can contribute to an understanding of how individual interest develops over time. The means through which students become highly domain identified involves many factors that are internal (e.g. *goals and beliefs*) and external (e.g. *family environment and educational experiences*) to them. Students who are more identified with an academic domain tend to demonstrate increased motivation, effort, perseverance (when faced with failure), and achievement. Importantly, students with lower domain identification tend to demonstrate less motivation, lower effort, and fewer desirable outcomes. Student outcomes in a domain can reciprocally influence domain identification by reinforcing or altering it. This feedback loop can help explain incremental changes in motivation, self-concept, individual interest, and, ultimately, important outcomes such as achievement, choice of college major, and career path. This dynamic model presents possible mechanisms for influencing student outcomes. Furthermore, assessing students' domain identification can allow practitioners to intervene to prevent undesirable outcomes. Finally, we present research on how mathematics and science instructors could use the principles of the MUSIC Model of Academic Motivation to enhance students' domain identification, by (a) empowering students, (b) demonstrating the usefulness of the domain, (c) supporting students' success, (d) triggering students' interests, and (e) fostering a sense of caring and belonging. We conclude that by using the MUSIC model, instructors can intentionally design educational experiences to help students progress from a situational interest to one that is more enduring and integrated into their identities.

Keywords

academic interest, math and science education

Disciplines

Education | Educational Psychology | Science and Mathematics Education

Fostering Students' Identification With Mathematics and Science

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The primary purpose of this chapter is to explore the process whereby students transition from a short-term, situational interest in mathematics or science to a more enduring individual interest in which they incorporate performance in mathematics or science into their self-definitions (e.g., "I am a scientist"). We do so by examining the research related to domain identification, which is the extent to which students define themselves through a role or performance in a domain, such as mathematics or science. Understanding the process of domain identification is important because it can contribute to an understanding of how individual interest develops over time. The means through which students become highly domain identified involves many factors that are internal (e.g., goals and beliefs) and external (e.g., family environment and educational experiences) to them. Students who are more identified with an academic domain tend to demonstrate increased motivation, effort, perseverance (when faced with failure), and achievement. Importantly, students with lower domain identification tend to demonstrate less motivation, lower effort, and fewer desirable outcomes. Student outcomes in a domain can reciprocally influence domain identification by reinforcing or altering it. This feedback loop can help explain incremental changes in motivation, self-concept, individual interest, and, ultimately, important outcomes such as achievement, choice of college major, and career path. This dynamic model presents possible mechanisms for influencing student outcomes. Furthermore, assessing students' domain identification can allow practitioners to intervene to prevent undesirable outcomes. Finally, we present research on how mathematics and science instructors could use the principles of the MUSIC Model of Academic Motivation (Jones, 2009) to enhance students' domain identification, by (a) *empowering* students, (b) demonstrating the *usefulness* of the domain, (c) supporting students' *success*, (d) triggering students' *interests*, and (e) fostering a sense of *caring* and belonging. We conclude that by using the MUSIC model, instructors can intentionally design educational experiences to help students progress from a situational interest to one that is more enduring and integrated into their identities.

Introduction

Basic Tenets of Domain Identification

Could I have been a parking lot attendant?
Could I have been a millionaire in Bel Air?
Could I have been lost somewhere in Paris?
Could I have been your little brother?
Could I have been anyone other than me?
Could I have been anyone other than me?
Could I have been anyone other than me?
Could I have been anyone?
—Dave Matthews Band, “Dancing Nancies” (1994)

Most of us have long lists of possible identities to explore as we develop and define our “selves.” Dave Matthews’s ruminations on the nature of identity in the opening quotation resonate with the classic writings of William James (1890) on the subject more than a century prior: “So the seeker of his truest, strongest, deepest self must review the list carefully, and pick out the one on which to stake his salvation” (p. 310). James also contended that one’s feelings about oneself depended on successes compared with aspirations, most keenly felt in activities related to the truest, most valued, self. Consider the Olympic Games, in which athletes who aspire to be the best in the world can be devastated to receive a silver or bronze medal instead of a gold medal. As James noted, it does not matter that these feats are unattainable by almost anyone else in the world. If the goal is to be the best and one fails, it is traumatic to the self; conversely, being inept at a task while holding no aspirations for that domain causes no grief to the individual. These examples remind us that the way individuals construct and define their senses of self is important. Individuals feel better when they succeed in valued domains and feel worse when they do not achieve their aspirations in those domains. Thus, the

structure of the self motivates individuals to succeed in those domains with which they most strongly identify.

These are the basic tenets of domain identification, and since the late 19th century, researchers have extended James's (1890) ideas and provided empirical evidence to support them. For example, contemporary researchers have found that the structure of an individual's self-perceptions is multidimensional and hierarchical (e.g., Marsh, 1990; Shavelson, Hubner, & Stanton, 1976).¹ Furthermore, individuals value some domains of the self more than others and will choose to increase or decrease the importance of these domains to maintain their overall positive feelings about themselves (Harter, 1986).

Although scholars have debated about whether all of James's ideas can be demonstrated empirically using quantitative methods (for a discussion, see Hardy & Moriarity, 2006; Marsh, 1995; Pelham, 1995), evidence supports a relationship between students' domain identification and their academic motivation and outcomes (Osborne, 1997a; Osborne & Jones, 2011).

Purpose

We seek to explore how students transition from a short-term, situational interest to a more enduring individual interest in which they incorporate performance in mathematics or science into their self-definitions (i.e., how students become identified with mathematics or science). This transition is crucial, yet lacking for students who fail to develop an enduring interest in these domains. We initially focus on defining domain identification and related constructs, demonstrating the effects of feedback on self-

¹ *Multidimensional* refers to the fact that an individual has many types of self-concepts, such as a mathematics self-concept and a science self-concept, whereas *hierarchical* refers to the fact that an individual's science self-concept can be composed of other self-concepts, such as a physics self-concept and a chemistry self-concept.

concept and self-esteem, explaining the process of domain identification, and discussing measures of domain identification. Then, we compare domain identification with interest by considering how students transition from a situational interest to an individual interest and domain identification. Particularly, we examine how instructors can facilitate this transition using principles from the MUSIC Model of Academic Motivation (Jones, 2009) by (a) *empowering* students, (b) demonstrating the *usefulness* of the domain, (c) supporting students' *success*, (d) triggering students' *interests*, and (e) fostering a sense of *caring* and belonging.

Explanation of Domain Identification

Definitions of Domain Identification and Related Constructs

Domain identification is “the extent to which an individual defines the self through a role or performance in a particular domain” (Osborne & Jones, 2011, p. 132). In essence, domain identification is the degree to which an individual values a domain as an important part of the self. In the context of schooling, a domain can be thought of more generally as “academics” or more specifically as a school subject such as “mathematics” or “science.” Researchers who study the self generally assume that identification can vary across domains. For example, a student could identify with academics more than sports or music; or within the broad domain of academics, a student could identify with mathematics more strongly than science or history. While identifying less with sports than academics, a student could still identify with tennis more than running or swimming.²

² It is unknown whether there is an optimal number of domains with which a psychologically healthy student should be highly identified, but as Osborne and Jones (2011) speculated, it seems reasonable to assume that most psychologically healthy individuals have several domains with which they strongly identify (see Osborne, 2004, for a discussion of potential problems with nondiverse selves).

Because definitions of “self” constructs can differ, we want to define them clearly in this chapter. We define “self-efficacy” as one’s judgment of his or her capabilities to successfully perform a particular task (Bandura, 1986), such as “I am somewhat confident that I can correctly solve double-digit multiplication problems.” We view self-concept and self-esteem as two separate constructs (e.g., Harter, 1998). We define *domain self-concept* as one’s perception of competence in a domain (e.g., Bong & Skaalvik, 2003). Mathematics and science self-concepts may be revealed with remarks such as “I am good at math” and “I tend to get B’s in science.” We define *domain self-esteem* as how a student feels about his or her self-concept in a domain, which can be evidenced by comments such as “I am proud of my math ability” (mathematics self-esteem) or “I am upset about my knowledge of science” (science self-esteem). These definitions separate a student’s domain competence (self-concept) from his or her emotional reactions (self-esteem) (e.g., Eccles & Wigfield, 1995; Harter, 1982). Finally, we define *global self-esteem* as an overall evaluation of the self as a person of worth, as evidenced by the statement “On the whole, I am satisfied with myself” (Rosenberg, 1979).

Effects of Feedback on Self-Concept and Self-Esteem

Symbolic interactionist view. Our concept of domain identification is rooted in the symbolic interactionist view of the self (Cooley, 1902; James, 1890; Mead, 1934), which posits that (1) students receive feedback in the schooling environment, (2) students selectively pay attention to some feedback, (3) feedback attended to is perceived, (4) students assess whether the feedback is an accurate or valid representation of their ability, (5) valid feedback (as assessed by the students) is incorporated into their domain self-

concept, (6) students evaluate their domain self-concepts, and (7) students incorporate that new feedback into their domain self-esteem, which then (8) influences their global self-esteem to the extent that they are identified with that domain. Figure 1 shows an example of this process in the domain of mathematics.

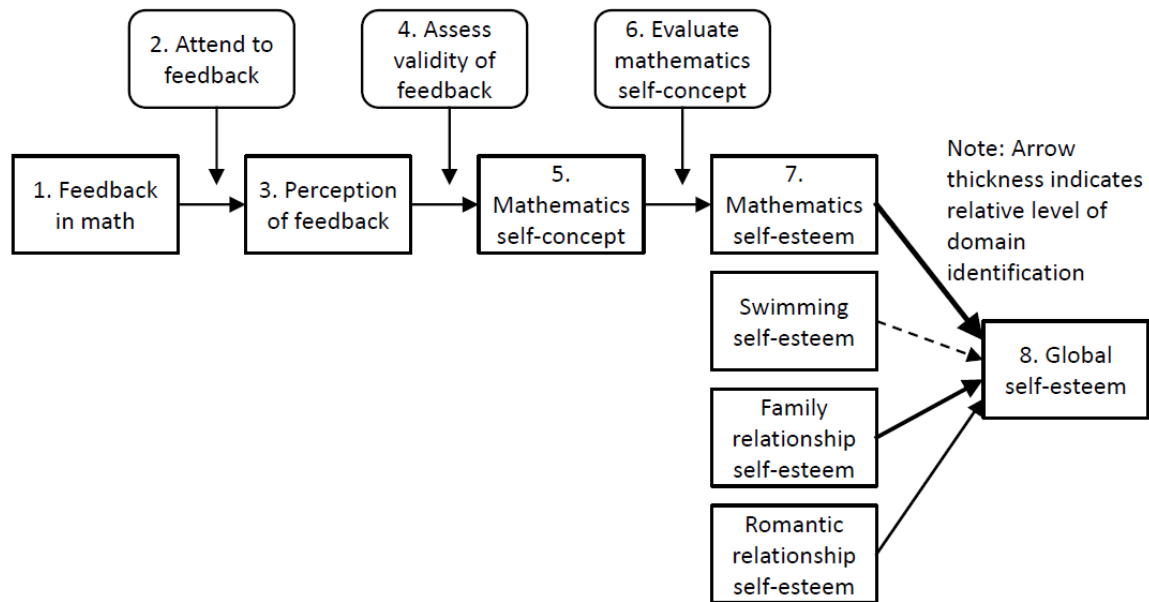


Figure 1. The effects of feedback in mathematics on global self-esteem (top two rows) and the effects of the relative level of identification of several domains on global self-esteem. The complete models for the nonmathematics domains are not shown but would be similar to the top two rows for mathematics.

Example of the effects of feedback on self-concept and self-esteem. Consider an example that refers to the numbers in Figure 1. Mia is a 10th grade student who just received a grade of 87% on a mathematics unit test (1). Because she had studied hard for this test, she was curious to know her grade on it (2). Her perception is straightforward in

that it only involves reading the percentage correct on the test (3).³ She believes that the test was graded fairly and that the grade is a reasonable assessment of her knowledge; thus, she accepts the validity of the feedback (4). This grade was a little lower than her current A- (91%) average in the course, but not lower enough to warrant a substantial change in her mathematics self-concept (5). As she talked to her classmates, she learned that no one received a grade higher than hers (6). As a result, she was pleased with her performance on the test, and she felt good about her achievements in mathematics this year (7). She has considered a career as an engineer, or maybe a video game designer, and others have told her that mathematics is important for these types of careers. Because of this, doing well in mathematics is important to her and she wants to do well in this mathematics class.

To understand the effects of Mia's mathematics test grade on her global self-esteem (8), it is necessary to understand how her mathematics identification compares with her levels of identification in other domains. Domains influence students' global self-esteem to different extents depending upon their levels of identification with the domains. When students have stronger identification with a domain, successes and failures in that domain have more of an effect on their self-esteem. In Figure 1, Mia's level of identification is represented by the width of the arrows leading to the "global self-esteem" rectangle. Mia is most strongly identified with mathematics because receiving good grades in high school will allow her to attend a reputable college and increase the chances that she will be able to pursue the career of her choice. But, in addition, she is a member of her high school swimming team, she has good relationships

³ This is not always true. Feedback on student essays or projects, for example, can be vague and misperceived easily.

with her family, and she is interested in continuing a relationship with a person she started dating recently. The domains with which she is most highly identified will have more of an effect on her global self-esteem than the other domains. Furthermore, her mathematics test grade will have a larger effect on her mathematics self-concept and mathematics self-esteem than on her global self-esteem, because her global self-esteem is also affected by her self-concept and self-esteem in the other domains.

The Process of Domain Identification

A model of domain identification. The model of domain identification described by Osborne and Jones (2011) explicates the process by which a set of social and academic background factors affect one's domain identification and motivation beliefs, which affect behavioral and academic outcomes. A modified version of this model is shown in Figure 2 for the domain of science. Here, we explain the process of identification shown in this figure by using an example of a 7th grade girl named Charlotte who is becoming more strongly identified with the domain of science. Charlotte's science identification has been influenced by her well-educated parents, one of whom works in a scientific field. Her parents have tried to provide her with positive informal science experiences outside of school, and her science identification has also been shaped by the types of public schools that she attended and her experiences in science classes. She is doing well in her science class this year, and it is important to her to do well in science. In fact, this high level of science identification led her to choose and engage in science-related activities when possible, put forth effort in them and in her science class, and persist when faced with challenging science problems. Her effort and persistence have led to positive engagement behaviors, which allowed her to be

successful in science class. The positive outcomes have reinforced her high science identification and motivation-related beliefs.

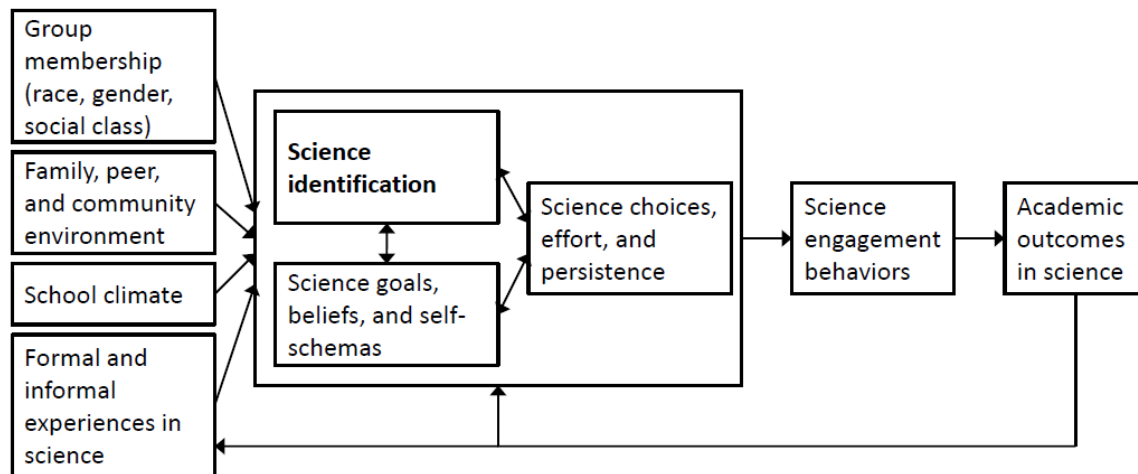


Figure 2. Precursors and consequences of science identification (modified from Osborne & Jones, 2011).

Charlotte has strong science identification in part because of the social and academic support she receives. However, many students face obstacles that challenge them at various points in this domain identification model. Charlotte’s friend Olivia has not had the same positive family support and fun informal science experiences, but she has experienced the same negative cultural messages about science not being “cool,” particularly for girls and women. She has the same science teacher as Charlotte and enjoys science class, but has not thought of herself as someone who could be a scientist. Because of her lower science identification, it is unlikely that she will choose to engage in science activities or classes when given the choice in the future. She does not put forth as much effort in science class as Charlotte, and she does not persist when faced with

challenging tasks. She will pass science class this year and the standardized science tests that she will have to complete in the future, but she will lack the science identification, as well as the goals, beliefs, and self-schemas to consider seriously a science-related career.

Evidence for the domain identification model. Several researchers have provided evidence for this model of domain identification. Walker, Greene, and Mansell (2006) showed, in a study of upper-level undergraduates, that identification with academics was positively correlated with self-efficacy and meaningful cognitive engagement and negatively related to a lack of motivation. They also found that identification with academics, as measured with Osborne's (1997a) School Perceptions Questionnaire, was statistically correlated with self-efficacy, intrinsic motivation, and meaningful cognitive engagement. Upon entering high school, students' academic identifications have been 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 negatively correlated with absenteeism and behavioral referrals (Osborne & Rausch, 2001; Osborne & Walker, 2006). At the college level, identification with academics has been shown to significantly predict grade point average after one semester and again after 2 years, even when controlling for sex, race, and self-esteem. In addition, high academic identification measured upon entering community college was related to positive academic outcomes such as achieving dean's list or honors standing, whereas low academic identification was related to withdrawal, academic dismissal, or academic probation (Osborne, 1997a).

Measures of Domain Identification

Domain identification has been assessed primarily with quantitative measures. Some researchers have classified students as having high domain identification if they enrolled in challenging academic courses or scored highly on standardized tests (e.g., Spencer, Steele, & Quinn, 1999). We find this method of classifying students problematic because students' selection of courses and standardized tests scores might not correlate with their levels of domain identification. An example would be a student who is not highly identified with mathematics but enrolls in higher level mathematics courses and does well in mathematics because he or she wants to increase the likelihood of acceptance into a particular college. Some researchers have supplemented these types of indicators with quantitative questionnaire items to measure students' perceived ability in or value of the domain, such as "Considering all the things that matter to you and make you who you are (e.g., friends, family, activities, sports, talents, etc.) how important is academic achievement?" (rated on a 7-point scale from *low* to *high*; Aronson, Fried, & Good, 2002, p. 120).

Osborne (1997a) developed the 16-item School Perceptions Questionnaire, which can be used to (a) measure a student's identification with academics or school, (b) examine more specific outcomes related to identification with academics, and (c) provide a tool that could potentially help community colleges target students with low academic identification for interventions to improve academic outcomes. An example item is "I enjoy school because it gives me a chance to learn many interesting things" (rated on a 7-point scale from *strongly disagree* to *strongly agree*; Osborne, 1997a, p. 63). Voelkl (1996) published the Identification With School instrument to assess students' perceptions of belongingness (i.e., acceptance of and respect for the self by others in the

school and feelings of inclusion) and valuing (i.e., the extent to which schooling is an important institution in society and the material being learned is important and useful). More recently, researchers (e.g., Jones, Osborne, Paretti, & Matusovich, in press; Jones, Paretti, Hein, & Knott, 2010) have used a four-item measure of domain identification that was created by reverse coding the results of a “devaluing” instrument (Schmader, Major, & Gramzow, 2001). An example item is “Being good at engineering is an important part of who I am” (rated on a 7-point scale from *strongly disagree* to *strongly agree*; Jones et al., 2010, p. 336).

It is important to note that these quantitative instruments vary in the concepts measured. For example, Jones et al. (2010) included items related to value only, whereas Voelkl (1996) included items related to both value and belongingness. Furthermore, some instruments used with stereotype threat research included items related to perception of ability and interest in the domain (Smith & White, 2001). Given these differences, the continued development and validation of high-quality instruments to measure domain identification is needed. Such instruments should measure value for academics at the domain level and incorporate items that examine a participant’s value for the domain.

A Comparison of Domain Identification and Interest

Definition of Interest

Interest is a psychological state of engaging both cognitively and affectively with “particular classes of objects, events, or ideas” (Hidi & Renninger, 2006, p. 112). It is also a predisposition to reengage with this content over time and is composed of the knowledge, stored value, and feelings related to the content which result from the individual’s engagement with the content over time (Renninger, 2010). This definition

integrates prior research on both situational and individual interest. Researchers examining *situational interest* have examined the types of activities that “trigger” or “catch” interest, with the understanding that this type of interest emerges from specific features in the environment and may be context specific (e.g., Mitchell, 1993; Schraw & Lehman, 2001). Researchers examining *individual interest* have focused on the effects of interest on learners’ responses to learning situations (e.g., Renninger, 2000; Renninger & Wozniak, 1985; Schiefele & Krapp, 1996).

The Four-Phase Model of Interest Development (Hidi & Renninger, 2006) connects the research on situational and individual interest by specifying a possible developmental progression through two types of situational interest (triggered and maintained situational interest) and two types of individual interest (emerging and well-developed individual interest). Situational interest is often initially triggered by external activities or content but becomes progressively more internally motivated and domain based (e.g., moving from interest in a class activity to a long-term, mostly internally guided interest in a school subject) as individuals develop positive feelings, knowledge, and value for the domain.

Similarities and Differences Between Domain Identification and Interest

The processes through which individuals develop their domain identification and interest are similar and complementary, but are not exactly the same conceptually. We focus our discussion here on the parallels between the development of domain identification and development that occurs when a maintained situational interest shifts to become an emerging individual interest. It is during this transition that individuals begin to self-identify with the domains in which they are interested (e.g., “I am a scientist”; see

Figure 3). During this time, their feelings, knowledge, and value for these domains continue to develop (Hidi & Renninger, 2006).

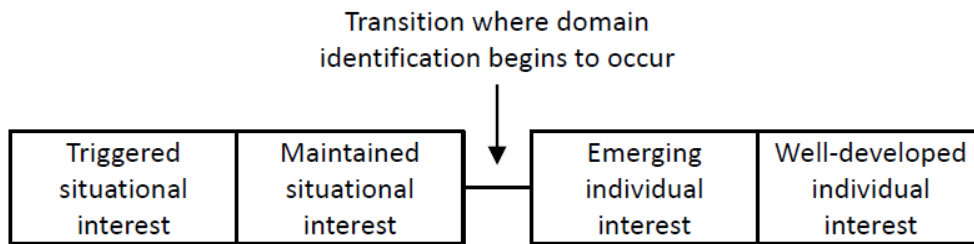


Figure 3. Domain identification begins to occur during the transition from situational to individual interest.

Similarities between domain identification and interest. Domain identification and interest are similar in that both develop through experience and can develop at any age. Even learners' initial situational interest in an activity or content is often connected to their prior experiences (Hidi & Harackiewicz, 2000). On the basis of the outcomes of their experiences, learners reevaluate their feelings or value for domains or content areas, particularly during the early phases of interest (Nolen, 2007). Similarly, learners who identify with a domain reevaluate their domain value if performance outcomes do not reflect their ability perceptions. Thus, developing value for the content or domain is a key component in this process for both domain identification and interest.

In the situational phases of interest, it is not likely that learners are aware of their potential interest in domains or content areas (Renninger, 2009). But as learners continue to progress to an emerging individual interest and begin to identify with domains or content areas, it is likely that they also become more aware of their interest, more self-regulated in their learning, and more capable of selecting experiences that support the development of their interest (Renninger, 2010). Without supportive conditions, however,

domain identification and interest can go dormant, regress, or disappear (Renninger, 2009).

Differences between domain identification and interest. Domain identification and interest differ in the level of their focus and the definition of value. The domain identification literature generally refers to a domain as a broader field or content area, such as academics, science, physics, or engineering. In comparison, learners initially may develop an interest in a particular topic or task within a content area, such as dissection in biology or exothermic reactions in chemistry, and not immediately incorporate it as part of the self (Renninger, 2009). As interest develops from a maintained situational interest into an emerging individual interest, this type of identification may begin. For example, someone could shift from a maintained situational interest in exothermic reactions to an individual interest in chemistry, and the shift in his or her interest may be accompanied by a change in identification.

Furthermore, the definition of “value” is different in the domain identification and the literature on interest. Selective valuing for a domain is the central aspect of domain identification (Osborne, 1997a, 1997b; Osborne & Jones, 2011), referring to a relative ordering of importance of domains within the self (Harter, 1986; Tesser & Campbell, 1980). As shown in Figure 1, mathematics might be more central to the self (i.e., more valued) than swimming or family relationships. In contrast, interest researchers use the term *stored value* to refer to feelings of competence and the emotions related to the engagement with the task, content, or domain (Renninger, 2000; Schiefele, Krapp, Prenzel, Heiland, & Kasten, 1983). Learners who gain competence in chemistry and who enjoy chemistry activities may also have developing interest in chemistry, whereas

learners who have low perceived competence in chemistry or who do not enjoy chemistry activities are likely to be in an earlier phase of interest development in chemistry.

In cases in which domain identification and interest align, the difference between the two definitions of value is likely to be of little practical significance. For instance, when students feel competent in and have positive emotions related to a domain (i.e., they have developed stored value), their domain identification (i.e., their selective valuing of the domain) probably increases. In contrast, when students feel incompetent in and have negative emotions related to a domain, their domain identification probably decreases. If domain identification and interest are conceptually distinct constructs, it should be possible to articulate examples of high domain identification and low interest, as well as low domain identification and high interest, as shown in Table 1.

Table 1

Examples of Different Levels of Stored Value and Selective Valuing

	High Domain Identification	Low Domain Identification
High interest	Students who have developed stored value for a domain and selectively value the domain as an important part of their self-concepts	Students who have developed stored value for a domain but do not value the domain as an important part of their self-concepts
Low interest	Students who have not developed stored value for a domain but who nevertheless do selectively value the domain as an important part of their self-concepts	Students who have not developed stored value for a domain and who do not value the domain as an important part of their self-concepts

High domain identification and low interest. Some students might have low levels of interest in a domain but be unable to avoid making it a valued aspect of their self-concepts and thus have high levels of domain identification. In these cases, external pressures from society, family, and peers can have strong effects on how students define

themselves. An instance of this would be a student who feels family pressure to become a doctor when he has low interest in and aptitude for biomedical science. Osborne (2004) explored the issue of high domain identification and low interest in relation to school violence by proposing that some students are frustrated when they are forced to identify with domains in which they consistently receive negative outcomes.⁴

Low domain identification and high interest. In contrast to the student who feels pressure to become a doctor but has low interest in doing so, some students might have high levels of interest in a domain but be unable to make it a central, valued aspect of their self-concepts. Family and societal expectations are one possible source of discordance between domain identification and interest, but age, sex, and racial norms can also play strong roles. This could be the case for a girl who enjoys and is interested in traditionally male pursuits (e.g., studying high-level mathematics or physics, programming computers, playing ice hockey) or a boy who is interested in traditionally female pursuits (e.g., cooking, working with young children, theatre). Although girls may see examples of women's pursuing these traditionally male pursuits and defining themselves through their pursuits, they may feel unable to identify with traditionally male domains because of familial or societal pressure to conform to gender-based expectations (Schmader, Johns, & Barquissau, 2004), and the same is true for boys who are unable to define themselves with traditionally female domains.

Furthermore, not all interests become central aspects of the self, even when society, family, and peers are supportive. As discussed previously, there are only so many

⁴ Through cultural or societal demands, individuals often selectively value dimensions on which they do not fare well. Numerous examples of this are possible. In the United States, for example, it is difficult to devalue affluence, physical attractiveness, and social standing, particularly at certain developmental phases, regardless of how one fares on these dimensions.

domains that can be central, defining (i.e., highly valued) aspects of the self. Thus, a boy who has many different abilities may enjoy biology, do well in the subject, and have a growing sense of competence, but still not consider biology as a centrally defining characteristic of his self because he is more highly identified with other domains.

Fostering Domain Identification

Role of the Instructor in Domain Identification

The primary aim of the present chapter is to explore the means through which students can become more highly identified with mathematics and science. We believe that examining ways to foster students' identification should also be applicable to transitioning students from maintained situational interest to emerging individual interest. To summarize what we have discussed about this process, several factors can help support or diminish students' domain identification, including group membership, family, peers, community environment, school climate, and educational experiences. The other factors shown in Figure 2 can also affect students' domain identification, likely in a cyclical manner. In this section, we focus specifically on the “formal and informal educational experiences” rectangle shown in Figure 2.⁵

The MUSIC Model of Academic Motivation

Many articles and books explain how instructors can provide educational experiences that are consistent with motivation research and theory (e.g., Schunk, Meece, & Pintrich, 2014). To make these instructional suggestions more accessible and applicable for instructors not steeped in motivation jargon, Jones (2009) developed the

⁵ We acknowledge that factors other than educational experiences may be more critical in influencing domain identification for some students. However, our purpose in this section is to discuss educational experiences specifically, because these experiences can be designed intentionally by instructors in ways that can affect students' domain identification.

MUSIC Model of Academic Motivation as an evidence-based, operational guide to translate and organize motivational theory and research into practical strategies that can be applied by instructors in any field. The five key principles of the MUSIC⁶ model are that students are more motivated when they perceive that they are *empowered*, the content is *useful*, they perceive that they can be *successful*, they are *interested*, and they feel *cared* for by others in the learning environment. The principles of the model were selected on the basis of an analysis, evaluation, and synthesis of motivation research and theories because these theories explain unique facets of students' motivation (Jones, 2009). Empirical evidence has verified the distinctiveness of the MUSIC model's components with students from the United States (Jones, 2010; Jones & Skaggs, 2012; Jones & Tendhar, 2014; Jones & Wilkins, 2013a, 2013b) and Egypt (Mohamed, Soliman, & Jones, 2013). It is important to recognize that the MUSIC model does not consist of new motivation constructs; instead, the principles of the model were worded to be understandable to practitioners, as opposed to including terminology familiar to motivation researchers (e.g., autonomy, utility value, self-efficacy; for a comparison of MUSIC model components and existing constructs, see Jones & Skaggs, 2012).

By incorporating the principles of the MUSIC model into instruction, instructors can create a motivating experience for students. Ideally, this experience would engage students by providing something similar to an “interest experience” whereby students' motivation “arises through an ongoing transaction among individuals' goals, activity characteristics, and the surrounding context” (Sansone & Thoman, 2005, pp. 175–176). However, even for students who do not have this type of experience, the principles of the MUSIC model should motivate students in other ways, such as by making the activities

⁶ “MUSIC” is an acronym for these five principles.

useful to their goals. It is also possible that with an instructor using the MUSIC principles, students will regulate their own interest for activities they consider to be useful (for more discussion of how this can occur, see Sansone & Thoman, 2005). Osborne and Jones (2011) provided evidence of how incorporating the MUSIC model's principles into instruction could increase students' domain identification more generally; in this section, we summarize how these principles can foster students' identification and interest in mathematics and science specifically.⁷

Empowering students. The empowerment component of the MUSIC model refers to the amount of autonomy students perceive within their learning environments. Autonomous students “feel like the ‘origin’ (deCharms, 1968) of their actions, and...have a voice or input in determining their own behavior” (Deci & Ryan, 1991, p. 243). It is important to note that this need for autonomy is not the same construct as “autonomy support,” which includes aspects of the autonomy construct, but it is defined more broadly (see Su & Reeve, 2011). Definitions of autonomy support typically include constructs such as interest, intrinsic motivation, competence, relatedness, sense of challenge, and intrinsic goals, which are included in other components of the MUSIC model. Instructors can empower students by allowing them to express their opinions and to make meaningful choices and decisions related to topics, materials, and strategies.

Inquiry-based teaching is a major focus of current science education teaching reforms (e.g., National Research Council, 2012), and an examination of inquiry-based science teaching has revealed positive effects on students' learning of science (Furtak, Seidel, Iverson, & Briggs, 2012; Minner, Levy, & Century, 2010). In particular, student

⁷ Other researchers have also proposed that constructs related to the MUSIC model's components can increase students' interest (e.g., Deci & Ryan, 1991, Krapp, 2005).

learning has been associated with teaching methods such as generating questions, designing experiments, collecting data, drawing conclusions, and other hands-on and active experiences with scientific or natural phenomena (Minner et al., 2010, p. 493). These methods provide students with some level of autonomy compared with teacher-directed activities. Minner et al. (2010) examined the effects of the level of student responsibility for learning and found that six of the nine studies that contrasted aspects of student responsibility for learning reported an increase in conceptual learning when there was more student responsibility in the instruction. Findings such as these allow us to make a strong theoretical case for how providing students with autonomy can lead to greater conceptual learning, which can result in higher achievement, higher competence perceptions, greater interest in science, and higher science identification. Several recent empirical studies support this theoretical linkage, documenting that when students were provided with autonomy in science or mathematics instruction, they also reported higher levels of intrinsic motivation (Berger & Hänze, 2009; Sturm & Bogner, 2008), interest experience (Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008), interest in science (Xu, Coats, & Davidson, 2012), and/or engagement (Hafen et al., 2012; Jang, Reeve, & Deci, 2010).

Demonstrating the usefulness of the class work. The usefulness component of the MUSIC model involves the extent to which students perceive that the class work (e.g., assignments, activities, readings) is useful for their short- or long-term goals (e.g., Eccles & Wigfield, 1995). When students perceive mathematics or science to be useful, they tend to be more interested in it.⁸ Instructors can demonstrate the usefulness of the content

⁸ As an example, Hulleman, Godes, Hendricks, and Harackiewicz (2010) demonstrated that perceived math usefulness predicted increases in triggered situational math task interest and maintained interest to reengage

by explaining to students how the material is related to their interests, career goals, and/or the real world, or by providing opportunities for students to engage in activities that demonstrate the usefulness of the content (for examples, see Jones, 2009).

Nieswandt and Shanahan (2008) reported that when 11th grade students in a general science class saw the usefulness of a science task, they “shifted their motivation from a performance orientation (desire to get through the class and get the credit) to a mastery orientation (desire to learn and to understand the material)” (p. 25). This switch in goal orientation is important because there is evidence that a mastery goal orientation can foster triggered and maintained situational interest (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008). As another example, Reynolds, Mehalik, Lovell, and Schunn (2009) explained how teachers created design-based learning (DBL) units in science and that these units “fostered engineering frames of mind by having student teams design a product to meet needs in their own lives” (p. 5). Thus, the instruction demonstrated to these high school students the usefulness of the topics. They found that compared with a control group, students who participated in the DBL units reported the following outcomes that would suggest that they were more highly identified with engineering: a higher level of interest in becoming an engineer and a higher level of interest in after-school or summer engineering programs.

Supporting students' success. The success component of the MUSIC model is based on the idea that students need to perceive that they can succeed at a task if they put forth the appropriate effort (e.g., Bandura, 1986). Students who perceive that they are successful believe that they are competent at class-related tasks and expect to do well on

in the math task in the future. In science, Ainley and Ainley (2011) showed that the perceived usefulness of science was related to embedded science interest and interest in learning science.

them. Success in a domain leads students to higher perceptions of competence and self-efficacy in domain tasks (Bandura, 1986). Importantly, students feel more successful when they accomplish challenging tasks than when they complete easy tasks. Instructors can foster students' success beliefs in a variety of ways, including making the class expectations clear, challenging students at an appropriate level, and providing students with feedback regularly (Jones, 2009).

Perceptions of competence and self-efficacy in mathematics and science are related to aspects of students' motivation to engage in these domains. In a study of 11th grade students, mathematics self-efficacy was found to predict students' career interests in mathematics and science (O'Brien, Kopala, & Martinez-Pons, 1999). Furthermore, higher self-perceptions of science ability for 5th to 11th grade students have been associated with a higher likelihood of taking more courses in science (Rudasill & Callahan, 2010). Success, as evidenced by good grades in mathematics and science, has also been found to predict whether adolescents participated in after-school mathematics- and science-related activities and continued with coursework in mathematics and science (Simpkins, Davis-Kean, & Eccles, 2006, p. 87). Students who choose to participate in after-school mathematics and science-related activities and choose to continue with coursework in these subjects are probably identified, at least to some extent, with these domains. Finally, success can be especially important in science because science courses are often perceived by students as being difficult, and thus, students believe that they need to be "smart" to do well in science (Shanahan & Nieswandt, 2011).⁹ Similarly,

⁹ This is an example of an internal, stable attribution. These tend to be demotivating when paired with poor performance. Yet teachers can guide students toward making internal, unstable attributions, such as "I need to study more next time" rather than "I am not smart enough."

success in mathematics appears to be critical to the mathematics identities of students, as documented in one study of high school girls (Horn, 2008).

Triggering students' interests. Jones (2009) recommends that instructors consider both situational and individual interest when designing for “interest” using the MUSIC model; however, we focus here on triggering students’ situational interest because we discuss ideas related to developing individual interest in other sections of the chapter. As discussed previously, individual interest starts with a situational interest in an object, event, or idea (e.g., Hidi & Renninger, 2006). Thus, one way of fostering students’ individual interest is for instructors to design a learning environment that triggers students’ situational interest. Students who have had their interest triggered pay attention to and enjoy instructional methods and class work. Instructors can trigger situational interest by designing instruction and class work that incorporate novelty, social interaction, games, humor, and surprising information, and/or that engenders emotions (for other ideas, see Bergin, 1999).

It is noteworthy that interest in science topics can vary by gender (Jones, Howe, & Rua, 2000). As an example, when scientific concepts were presented to girls in the context of culturally feminine topics, and boys in the context of culturally masculine topics, their scientific topic interest tended to be higher (Kerger, Martin, & Brunner, 2011). Furthermore, Hoffmann (2002) demonstrated that when 7th grade physics instruction was oriented to girls’ and boys’ interests, both girls and boys showed higher achievement. Studies such as these demonstrate that gender should be considered when selecting interesting topics to ensure that all students’ interests are addressed.

Caring for students. The caring component of the MUSIC model involves the extent to which students believe that the instructor or other students care about whether they succeed in the class work (academic caring) and care about their well-being (personal caring; Jones & Wilkins, 2013a). Students who feel cared for perceive others' caring through actions such as others' listening to them, helping them with their academic needs, and being respectful of them (e.g., Noddings, 1992). To support academic caring, instructors can demonstrate that they care about whether students successfully meet the class objectives; and to support personal caring, instructors can demonstrate that they care about students' general well-being and welfare (Jones, 2009).

At many different levels of schooling, researchers have documented the importance of caring relationships for the motivation and identity development of the students. At the kindergarten level, caring relationships between students and instructors predicted positive motivational beliefs (Patrick, Mantzicopoulos, Samarapungavan, & French, 2008). At the middle school level, a caring mathematics teacher was found to be important to the mathematics identity of African American boys (Berry, 2008). In a study of successful minority women (Johnson, Brown, Carlone, & Cuevas, 2011), researchers provided an account of how a Latina woman came to author her identity in the sciences through the time that she spent at mathematics and science programs with her friend. This is a good example of how a caring peer can provide the motivation to engage in science. Furthermore, Stake and Nickens (2005) reported that peer relationships in science were associated with the likelihood that rising juniors and seniors could see themselves as scientists in the future. These types of studies have demonstrated the importance of caring relationships among students and between students and instructors.

All of the MUSIC model's components together. Although a substantial amount of evidence exists to demonstrate how each component of the MUSIC model can affect students' domain identification and interest, less research has focused on how the five MUSIC components work together to do so. However, recent findings in the engineering domain are promising. In two separate quantitative studies with two different samples of students, Jones et al. (in press) and Tendhar and Jones (2014) documented that first year university engineering students' perceptions of the MUSIC model components in their second university engineering course (in the spring of their first year of college) predicted their levels of engineering identification, as measured with the four-item scale from Jones et al. (2010). This is important evidence to support the contribution of students' perceptions of the MUSIC model components to their identification because these studies were the first to include *all* of the MUSIC components as variables in one analysis. In the Jones et al. (in press) study, all five of the MUSIC components uniquely predicted students' engineering identification, even when controlling for the effects of the other four components. In the Tendhar and Jones (2014) study, all of the MUSIC components except situational interest predicted students' engineering identification. Moreover, these studies show that the MUSIC components are distinct, yet correlated, aspects of instruction that can be measured and perceived independently, as has also been reported by others (Jones & Skaggs, 2012; Jones & Wilkins, 2013a, 2013b; Mohamed et al., 2013).

The importance of the MUSIC model components was also evident in interviews with first year undergraduate physics and biochemistry majors' descriptions of their

interest in and identification with their major (Ruff, 2013). The themes that emerged from students' descriptions of how they developed an interest in the academic topics related to their major coincided with or included all of the five MUSIC model components.

Although further research is needed to examine how students specifically perceive the MUSIC model components in connection with their developing interest in an academic field, this qualitative study provides additional validation that the MUSIC model components are a part of students' developing domain identification and individual interest in science disciplines.

Researchers who have used the MUSIC model to study students' motivation in out-of-school settings have also documented relationships among the MUSIC components and students' domain identification and interest. For example, when middle-school students worked on a science and engineering-design project during an afterschool program that was developed in ways consistent with the MUSIC model, students felt empowered, better understood the usefulness of engineering and science, felt that the project structure and instructors helped them succeed, became interested in and enjoyed the activities, and reported that the attention from the instructors and facilitators helped them feel supported and cared for (Schnittka, Brandt, Jones, & Evans, 2012).

Furthermore, the authors reasoned that these student perceptions led them to become more identified with science and engineering and to put forth high effort in the activities. In another afterschool program, Evans, Jones, and Biedler (2014) used the MUSIC model to examine how learning science concepts through video games affected high school students' motivation and argued that this type of informal learning experience could have positive effects on students' interests and values related to science.

Concluding Thoughts

The aim of our research has been to examine factors in learning environments that can lead to longer-term individual interests in which students become identified with a domain. A substantial amount of evidence indicates that each of the MUSIC Model of Academic Motivation components (and closely related constructs) is important to developing students' domain identification. Yet research that includes all of the MUSIC model components in one model and considers the relationships among the components is in its infancy. The initial evidence indicates that all of the MUSIC components can predict some unique aspect of students' domain identification. Given these findings, we contend that to increase the domain identification and more enduring interest of all students, instructors should intentionally design instruction with a consideration of all five of the MUSIC model principles, including empowering students, demonstrating the usefulness of the content, ensuring that students perceive that they can succeed at challenging tasks, triggering students' interest, and caring for students. Consistent experiences such as these increase the likelihood that students will adopt the domain as an important aspect of their selves, leading to an expectation of increased success in that domain.

Next Steps for Researchers

We end by identifying several areas that could benefit from further research. First, researchers need to continue to explain and clarify the similarities and differences between domain identification and interest. Although the construct definitions overlap, they are distinct constructs with separate theoretical traditions. Understanding the similarities and differences could help strengthen the distinctiveness of both.

Second, researchers need to further explore how domain identification and interest develop. Both identification and interest develop via cyclical dynamics over periods of time, but this process has not been fully explained. Evidence indicates that the MUSIC model components play an important role in the process, but it is unknown how these components interact to affect one another and the other outcomes in the domain identification model. It is reasonable that this process is complex, with domain identification and interest waxing and waning over long periods of time, either together or independently. Much of the work we cited clearly demonstrated the link between selective valuing of a domain and success or failure outcomes in that domain, but those studies were not longitudinal or developmental. Although some researchers have explored longer term studies of related constructs (e.g., Simpkins et al., 2006), more research is needed.

Third, researchers need to better understand which factors influence domain identification and interest and how they influence these constructs. It would be desirable to study multiple predictive factors that can affect these constructs simultaneously in the context of a single study, providing an understanding of the relative importance of these factors in different contexts with different populations at different developmental stages. As an example, Jones et al. (in press) included constructs related to empowerment, usefulness, success, interest, and caring in their statistical model and showed that all of these factors were predictors of students' domain identification, even after controlling for the other variables. Although highly desirable, these types of analyses need relatively large samples and are complicated further when performed longitudinally.

Fourth, although Osborne and Jones (2011) presented an evidence-based theoretical model, researchers need to provide empirical support for the linkages in the model in multiple populations. This model acknowledges that students do not exist solely in classrooms. Social and environmental factors, as well as personal factors, can influence the development of both domain identification and interest. One need is to determine whether some of the MUSIC model's components are more important than others in fostering students' domain identification in a given population with different mathematics and science activities. Another need is to study how interest relates to stereotype threat. There is already a well-developed discussion concerning Steele's (1997) theory of stereotype threat and domain identification. It would be worthwhile to consider how interest might play into, or be affected by, cultural stereotypes of inferiority, and whether there are ways to help students belonging to traditionally stigmatized groups maintain interest in domains in which they are stigmatized despite cultural signals to the contrary.

Finally, aside from these conceptual and theoretical concerns, researchers need to better understand how these constructs can be used to improve educational outcomes for students in mathematics and science. Because a lack of interest in schooling is probably indicative of future problems (Finn & Rock, 1997), it would be useful to determine whether monitoring students' domain identification or interest would allow school counselors and educators to identify those at risk for problems prior to the problems' becoming evident. As discussed previously, some of the academic identification research suggests that it may be a leading indicator of future success or challenge. Addressing the needs presented in this section would lead to a better understanding of the constructs and

processes involved in transitioning students from a situational interest to an individual interest in which they become identified with the mathematics and science domains.

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