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Using psychological constructs from the MUSIC Model of Motivation to predict students' science identification and career goals: results from the U.S. and Iceland

Brett D. Jones[a], Sumeyra Sahbaz[b], Asta B. Schram[c] and Jessica R. Chittum[d]

[a]School of Education, Virginia Tech, Blacksburg, VA, USA; [b]School of Educational Studies, Oklahoma State University, Stillwater, OK, USA; [c]School of Health Sciences, University of Iceland, Reykjavik, Iceland; [d]Department of Elementary Education and Middle Grades Education, East Carolina University, Greenville, NC, USA

ABSTRACT

We investigated students' perceptions related to psychological constructs in their science classes and the influence of these perceptions on their science identification and science career goals. Participants included 575 middle school students from two countries (334 students in the U.S. and 241 students in Iceland). Students completed a self-report questionnaire that included items from several measures. We conducted correlational analyses, confirmatory factor analyses, and structural equation modelling to test our hypotheses. Students' class perceptions (i.e. empowerment, usefulness, success, interest, and caring) were significantly correlated with their science identification, which was correlated positively with their science career goals. Combining students' science class perceptions, science identification, and career goals into one model, we documented that the U.S. and Icelandic samples fit the data reasonably well. However, not all of the hypothesised paths were statistically significant. For example, only students' perceptions of usefulness (for the U.S. and Icelandic students) and success (for the U.S. students only) significantly predicted students' career goals in the full model. Theoretically, our findings are consistent with results from samples of university engineering students, yet different in some ways. Our results provide evidence for the theoretical relationships between students' perceptions of science classes and their career goals.

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Motivation; attitudes; K-12

Students' interest in science during their middle school years can be an important predictor of their eventual decisions to pursue science-related college degrees and careers (Riegle-Crumb, Moore, & Ramos-Wada, 2011; Tai, Liu, Maltese, & Fan, 2006). Although students' interest in science and science identity often deteriorates as they move from the elementary to middle grades (Carlone, Scott, & Lowder, 2014; Osborne, Simon, & Collins, 2003), their educational environment can positively impact their motivational beliefs and long-term persistence (Fortus & Vedder-Weiss, 2014; Vedder-Weiss & Fortus, 2011). This is important because science literacy has been cited as critical to preparation for all careers

CONTACT Brett D. Jones brettjones@vt.edu School of Education (0313), Virginia Tech, Blacksburg, 24061 VA, USA

in the modern workforce (Next Generation Science Standards, n.d.). To better understand the factors that contribute to students' identification with science and science career goals, we investigated students' perceptions of five motivation-related constructs in their science class and the influence of these perceptions on their science identification and science career goals.

Theoretical frameworks

Domain identification

Identification with a domain (e.g. science identification) refers to the extent to which the domain is an important part of an individual's identity; that is, the extent to which an individual values the domain as an important part of his or her self (Jones, Ruff, & Osborne, 2015; Osborne & Jones, 2011). Domain identification has been linked to positive outcomes, such as classroom participation and achievement (Voelkl, 1997), deep cognitive processing of course material and self-regulation (Osborne & Rausch, 2001; Walker, Greene, & Mansell, 2006), grade point average and academic honours (Osborne, 1997), decreased behavioural referrals and absenteeism (Osborne & Rausch, 2001), persistence in an undergraduate major (Jones, Ruff, & Paretti, 2013), and career goals (Aschbacher, Ing, & Tsai, 2014; Jones, Osborne, Paretti, & Matusovich, 2014; Jones, Tendhar, & Paretti, 2016)

Osborne and Jones (2011) presented a model of domain identification that showed several factors that could affect students' domain identification, including group membership (race, gender, social class); family, peers, and community environment; school climate; and formal and informal educational experiences. Subsequently, domain identification interacts with students' goals, beliefs, and self-schemas, and it predicts several factors, such as choices, behaviours, effort, persistence, and ultimately, academic outcomes. Although we acknowledge that all of these factors may affect students' science identification and career goals, we focused our study on students' perceptions of their formal educational experiences because these perceptions are more directly influenced by teachers in the classroom.

When considering factors in students' formal educational experiences, Osborne and Jones (2011) cited research demonstrating how the components of the MUSIC® Model of Motivation (i.e. MUSIC model; Jones, 2009, 2015; described in the next section) could be especially useful for teachers to consider when intentionally designing instruction to develop students' domain identification. Since then, empirical evidence has demonstrated that students' perceptions of the MUSIC model components are related to their identification in the domain of engineering (e.g. Jones et al., 2014; Jones, Tendhar, et al., 2016; Tendhar, Singh, Jones, Creamer, & Paretti, 2016). Therefore, we suspected that these same factors could predict students' identification in the domain of science (as indicated by the bold text in Figure 1). In the next section, we explain the MUSIC model in more detail and provide evidence of how the MUSIC model components are related to important outcomes in the domain of science.

The MUSIC Model of Motivation

Overview

The MUSIC model is a multidimensional model of motivation that was developed to provide instructors with an overview of current motivation research and theories, and

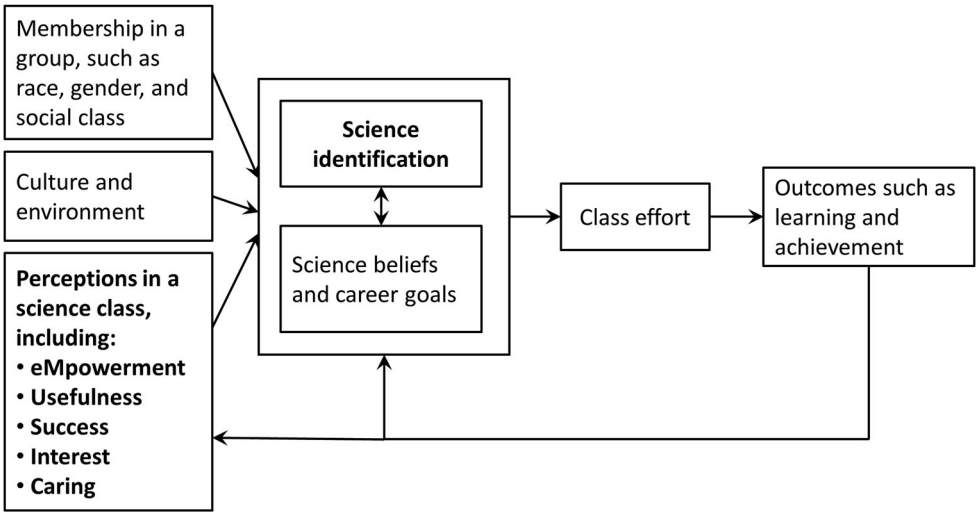

Figure 1. Antecedents and consequences of science identification. From "Overview of the MUSIC® Model of Motivation" (http://www.theMUSICmodel.com), by B. D. Jones, 2017 (March). Copyright 2017 by Brett D. Jones. Adapted with permission.

to serve as an organisational framework for designing instruction to engage students in learning (Jones, 2009, 2015). The MUSIC model uses the acronym 'MUSIC' to organise instructional implications for motivation into five key principles: Students are more motivated when (a) they perceive that they are *eMpowered*, (b) they perceive the class activities and assignments to be U*seful*, (c) they believe that they can be S*uccessful* in the class, (d) they are I*nterested* in the class topics, and (e) they feel C*ared* for by the teacher or other students. The MUSIC model does not create new motivation constructs; instead, it uses terminology that translates the jargon of motivation research into language that is more easily understood by practitioners who might not be familiar with motivation research. Researchers have provided validity evidence for the structure of the MUSIC model for use with elementary-aged students (Jones & Sigmon, 2016), middle and high school students (Chittum & Jones, in press; Parkes, Jones, & Wilkins, 2015), and college students (Jones & Skaggs, 2016; Jones & Wilkins, 2013). Moreover, constructs consistent with the MUSIC model components have been shown to be critical to students' motivation in a variety of subject areas (e.g. Bandura, 1986; Deci & Ryan, 2000; Hidi & Renninger, 2006; Noddings, 1992; Wigfield & Eccles, 2000), including science (e.g. Berger & Hänze, 2009; Hoffmann, 2002; Nieswandt & Shanahan, 2008; Palmer, 2009; Simpkins, Davis-Kean, & Eccles, 2006).

Empowerment

The *empowerment* component of the MUSIC model involves teaching strategies that provide students with the perception that they have control over some aspect of their learning in the classroom (Jones, 2009, 2015). Research findings suggest that provision of some empowerment during science instruction is positively associated with performance outcomes (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008; Mehalik, Doppelt, & Schuun, 2008), knowledge retention (Mehalik et al., 2008), intrinsic motivation

(Berger & Hänze, 2009; Sturm & Bogner, 2008), and engagement (Doppelt et al., 2008; Jang, Reeve, & Deci, 2010; Schwartz & Sadler, 2007). For example, Schwartz and Sadler (2007) found that when middle school science students were given control over how learning goals were accomplished, they learned more and were more engaged in the science tasks. Similarly, Doppelt et al. (2008) and Mehalik et al. (2008) found that middle school students who participated in design-based learning units in which they designed and led inquiry-based activities were more engaged and performed better than students who participated in more teacher-centred, traditional units.

The empowerment component also concerns communicating that students have autonomy through non-controlling language (e.g. 'you can' vs. 'you need to'). Basten, Meyer-Ahrens, Fries, and Wilde (2014) found that students were more highly engaged and motivated when fifth and sixth grade students' instructors used non-controlling language as they gave instructions and facilitated students' work during a science field trip.

Usefulness

The *usefulness* component of the MUSIC model involves teaching strategies designed to help students relate the class topics to students' short-term or long-term goals, or incorporate authentic and meaningful learning experiences by connecting learning tasks to the real world (Jones, 2009, 2015). Research indicates that when science instruction is focused on usefulness, students are often more engaged (Doppelt et al., 2008; Mehalik et al., 2008; Milner, Templin, & Czerniak, 2011), demonstrate better use of learning strategies (Milner et al., 2011), perform higher and retain knowledge (Doppelt et al., 2008; Mehalik et al., 2008), are more highly motivated (Milner et al., 2011; Sturm & Bogner, 2008), are more interested in specific science topics (Hiller & Kitsantas, 2014; Nieswandt & Shanahan, 2008), report higher self-efficacy (Hiller & Kitsantas, 2014), and report increased intentions to persist in science-related courses and careers (Reynolds, Mehalik, Lovell, & Schunn, 2009).

As an example, Mehalik et al. (2008) studied a design-based learning unit for middle school students. The unit was developed to emphasise the importance of the science topics, and the students were encouraged to formulate research questions based on their personal interests and goals, and then followed an authentic research design to pursue answers. Researchers found that the students in the design-based unit performed higher and were more engaged.

Success

The *success* component of the MUSIC model involves teaching strategies that help students to believe that they can succeed in the class. High expectancies for success and competence beliefs have been associated with the following: intentions to persist in science (e.g. pursue science careers, courses, and tasks; Debacker & Nelson, 2000; Degenhart et al., 2007; Hiller & Kitsantas, 2014; Ireson & Hallam, 2005; Rudasill & Callahan, 2010; Simpkins et al., 2006), increased engagement (Hoffmann, 2002; Scogin & Stuessy, 2015), higher performance (Hoffmann, 2002), increased strategy use (Cheung, 2015), and positive affect for science (Debacker & Nelson, 2000; Hoffmann, 2002).

Researchers have investigated strategies for designing science instruction to facilitate students' achievement (e.g. Jordan, Sorensen, & Hmelo-Silver, 2014). However, the success component of the MUSIC model is not about students' actual success; rather, it refers to strategies that lead to students' *perceptions* of success. That is, students need to

perceive that they can succeed. Of course, students' positive expectancies for success and ability perceptions (e.g. self-concept, self-efficacy; Bandura, 1997; Cheung, 2015) are often related to previous achievement (Schunk, 1989). In other words, when a student's achievement is high, s/he is more likely to believe that s/he can succeed in the future (Simpkins et al., 2006). In a study of middle school students, Ireson and Hallam (2005) found that the level of domain-specific self-concept was more important to students' intentions to continue studying than was their prior achievement.

Researchers have also examined interventions aimed at increasing students' achievement perceptions, such as self-efficacy (i.e. confidence in completing a specific task; Schunk, 1989). For example, researchers have documented that students' increased self-efficacy is influential in affecting their achievement and intentions to persist in STEM careers (Degenhart et al., 2007; Hiller & Kitsantas, 2014).

Interest

The *interest* component of the MUSIC model involves strategies that lead to students' interest in and enjoyment of class activities (Jones, 2009, 2015). Students' interests in science and science coursework have been positively associated with intrinsic motivation (Rieber, 1991), learning (Barak, Ashkar, & Dori, 2011; Rosen, 2009), engagement (Spiegel, McQuillan, Halpin, Matuk, & Diamond, 2013), perceived success (Barak et al., 2011; Hoffmann, 2002), perceived importance (Barak et al., 2011), and intentions to study science in the future (Jacobs, Finken, Griffin, & Wright, 1998; Rosen, 2009).

Interest can be viewed as both a short-term phenomenon that arises spontaneously in a particular situation (referred to as *situational* interest; Schraw, Flowerday, & Lehman, 2001) and as a longer term *individual* interest that lasts over time (Hidi & Renninger, 2006). Because the focus of our study was on factors that teachers could affect in their classrooms, we were most concerned with situational interest; and thus, the focus of our literature review in this section is on how situational interest affects outcomes in science.

Several studies have concentrated on influencing students' motivation in science through the use of novel, stimulating activities geared towards developing situational interest. For example, ninth and 10th grade biology students who read about viruses in comic books instead of in more traditional essays reported more interest in continuing to engage with the reading materials (Spiegel et al., 2013). Moreover, students who were less identified with science were significantly more interested in engaging with the comics in the future than the more highly identified students. Other researchers have investigated the use of animated graphics or movies to stimulate interest and they have found that the graphics and movies led to increases in motivation to learn science when compared to more static images and textbooks (Barak et al., 2011; Rieber, 1991; Rosen, 2009).

Caring

The caring component of the MUSIC model involves strategies that help students to feel cared about by others, such as their teacher and other students (Jones, 2009, 2015). When students feel cared for, they believe that the teacher (or other students) cares about whether or not they succeed in class and cares about them personally. Perceiving caring, supporting, and/or positive relations with others in the learning environment has been associated with increased engagement (Lee, 2002; Ryan & Patrick, 2001; Scogin & Stuessy, 2015), achievement (Jen, Lee, Chien, Hsu, & Chen, 2013), positive attitudes

about and values for science (Jen et al., 2013; Smart, 2009), science identity development (Lee, 2002; Stake & Nickens, 2005), intentions to persist in science (Jacobs et al., 1998; Stake & Nickens, 2005), and positive ability beliefs in science (Jen et al., 2013; Smart, 2009).

In part, the caring component of the MUSIC model concerns students' interactions and positive relationships with their *teachers* and *mentors*. For example, Smart (2009) found that middle school students' perceptions about their interactions with their science teachers predicted several motivational outcomes, such as their science self-efficacy and value for science. Teachers' interpersonal behaviours (e.g. academic support, friendliness, understanding) supported these positive outcomes. Less supportive behaviours, such as harshness and impatience, were associated with more negative motivational beliefs.

The caring component also concerns students' positive interactions with others in the learning environment and outside of school. As examples, positive peer relationships among high school science students have been associated with foreseeing the future self as a scientist and increased intentions to continue studying science (Stake & Nickens, 2005). Similarly, sharing positive science experiences with peers has been shown to influence students' interests in pursing science careers (Jacobs et al., 1998). In sum, evidence indicates that relationships built between students, teachers, parents, and mentors can all have positive effects on students' motivation and engagement in science-related tasks (Lee, 2002; Napper, Hale, & Puckett, 2002).

Research question and hypotheses

Our primary research question in this study was: To what extent are students' perceptions of the MUSIC model components (i.e. empowerment, usefulness, success, interest, and caring) in their science class related to their science identification and career goals? We identified the following three hypotheses:

> H1: Students' perceptions of the five MUSIC model components (i.e. empowerment, usefulness, success, interest, and caring) in science class will correlate positively with their science identification.
>
> H2: Students' science identification will correlate positively with their science career goals.
>
> H3: When included in the same model, students' perceptions of the five MUSIC model components in science class will predict their science identification, which in turn will predict their science career goals (as illustrated in Figure 2).

Although researchers have provided support for these hypotheses with samples of undergraduate engineering students (Jones et al., 2014; Jones, Tendhar, et al., 2016; Tendhar et

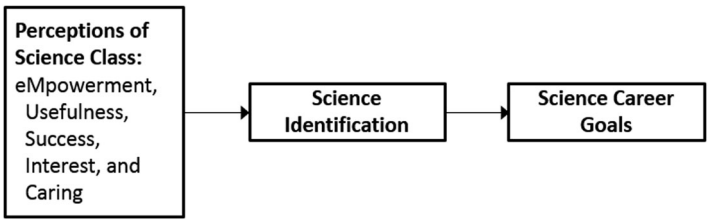

Figure 2. Relationships hypothesized between students' perceptions of their science classes, their science identification, and their science career goals.

al., 2016), these relationships have not been assessed together in one study in the domain of science at the K-12 level. Our sample included students in fifth through eighth grade because researchers have documented that it is important to nurture students' motivation prior to the eighth grade (Maltese & Tai, 2010; President's Council of Advisors on Science and Technology [PCAST], 2010, 2012) and formal preparation for students who intend to persist in the sciences typically begins during that time (National Academy of Sciences, 2007). Furthermore, we designed the present study to include a sample of Icelandic students because these hypotheses had not been tested in cultures outside of the U.S. Given that we had no precedent on which to base our hypothesis for the sample of Icelandic students, we used the same three hypotheses for both samples.

We chose to include Icelandic students in our study primarily because one of the authors is Icelandic and she had access to a convenience sample that closely matched our U.S. sample. As highly developed Western cultures, the U.S. and Iceland share many cultural similarities, such as customs and values. However, some significant differences exist, such as those related to the political and educational systems (Statistics Iceland, 2014). Although the U.S. is built on a more capitalistic ideology, Iceland is a republic with a parliamentary democracy and presidential elections by a popular vote. Iceland is also defined as a Welfare State, similar to the other Nordic countries due to its welfare system that includes socialised health insurance.

Although everyone in both the U.S. and Iceland has the right to a free education at the compulsory level, the organisation of education in Iceland is more centralised than in the U.S. Education is compulsory from kindergarten to 12th grade in the U.S. and from grades one to 10 in Iceland, but most Icelandic students move on from the compulsory school to another school level where they graduate with matriculation (an associate degree) at age 19 or 20, which gives them the right to enrol at the university level. About 77% of the schools in the U.S. receive public funding (National Center for Educational Statistics, n.d.), whereas almost all of the compulsory schools in Iceland are public and even the few small private schools in Reykjavik also receive public funds, which are always based on the number of students. This also applies for higher education in Iceland.

In spite of these differences, research indicates that students and teachers in Iceland face very similar challenges to those in the U.S. For example, students' academic motivation and interest tend to decrease with age, especially at the early secondary level (Björnsdóttir, Kristjánsson, & Hansen, 2008). The 2013 PISA results indicated that Icelandic 10th grade students have ranked only moderately on several motivational factors, for example, in science (Halldórsson, Ólafsson, & Björnsson, 2007, 2013). Furthermore, there has been a decline in students' achievement scores in scientific literacy from the 2006 PISA results. Less research has been conducted on these issues in middle school, but there is a reported decline in students' motivation and interest in middle school subjects, including science (Halldórsson et al., 2007), which probably continues to influence their 10th grade motivation and achievement.

Method

Participants

Participants from the U.S. sample included 334 students (170 male and 164 female) from three grade levels (110 fifth graders, 117 sixth graders, and 107 seventh graders) and two

schools (153 students from one school and 181 from the other) in rural Virginia. Most of the students self-reported as White ($n = 300$), whereas 31 students self-reported as Black or African-American, and three students did not report their race.

Participants from the Iceland sample included 241 students (97 male and 102 female; 42 students did not report their sex) from four grade levels (79 fifth graders, 73 sixth graders, 52 seventh graders, and 37 eighth graders) and three schools (117 from the first school, 81 from the second school, and 43 from the third school) in Iceland. Most of the students self-reported that they had Icelandic parents ($n = 209$), whereas 14 reported that they had foreign parents, 15 reported that they had a foreign mother, and three reported that they had a foreign father.

Data collection and instruments

Students in the U.S. and Iceland completed a paper-and-pencil, self-report questionnaire that included items from several different scales. The items in each scale were averaged to produce a scale score. An example item from each scale is provided in Table 1; all items were rated on a 6-point Likert-format scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The complete inventories in both English and Icelandic are available upon request.

MUSIC Model of Academic Motivation Inventory, middle school version. The middle school version of the MUSIC Model of Academic Motivation Inventory (MUSIC Inventory; Jones, 2016) consists of 18 items and has been shown to produce valid scores for upper-elementary and middle school students (Chittum & Jones, in press; Parkes et al., 2015). All of the students from Iceland completed the Icelandic versions of the MUSIC Inventory scales, which have been shown to produce reliable scores (Schram & Jones, 2016). Definitions of the five MUSIC Inventory constructs and their reliability estimates from the present study are shown in Table 2.

Science identification. The science identification measure was created by averaging four items used by Jones, Paretti, Hein, and Knott (2010) to measure students' engineering

Table 1. Number of items and an example item from each scale.

Scale	No. of items	Example item
Empowerment	4	I have choices in what I am allowed to do in science class.
Usefulness	3	In general, science class work is useful to me.
Success	4	I am confident that I can succeed in science class work.
Interest	3	The science class work is interesting to me.
Caring	4	My science teacher cares about how well I do in science class.
Science identification	4	Being good at science is an important part of who I am.
Science career goals	2	My future career will involve science.

Table 2. The MUSIC inventory constructs, their definitions, and reliability estimates.

MUSIC model constructs	Definitions The degree to which a student perceives that:	English α	Icelandic α
Empowerment	He or she has control of his or her learning environment in the course.	.72	.68
Usefulness	The coursework is useful to his or her future.	.80	.87
Success	He or she can succeed at the coursework.	.84	.83
Interest	The instructional methods and coursework are interesting.	.77	.86
Caring	The instructor cares about whether or not the student succeeds in the coursework and cares about the student's well-being.	.85	.88

identification. The word 'engineering' was replaced with 'science,' and the scale measured students' science identification: the extent to which students identify with (i.e. value) science. The scale was translated into Icelandic by one of the authors, a native Icelander, who was also a doctoral student at a U.S. university at that time. The Icelandic translation was then translated back into English (back-translated) by another individual whose native language was the target language (Villagran & Lucke, 2005). The individual who conducted the back-translation had not seen the original English version of the scale. The back-translation was then compared to the original English version by the first author, whose native language was English. The native English speaker found only a few discrepancies in the back-translation and worked with the translator and back-translator to resolve the issues until the inventory items were deemed to be acceptable by the English speaker and the translators. The reliability estimates in the present study for the English ($\alpha = .82$) and Icelandic ($\alpha = .91$) versions were good.

Science career goals. We measured the likelihood that students would choose a career involving science by averaging two items based on similar items used by Jones et al. (2014, 2016). The scale was translated into Icelandic using the same procedure described in the previous section. The reliability estimates in the present study for the English ($\alpha = .81$) and Icelandic ($\alpha = .85$) versions were good.

Analysis

To assess the reliability of the scores produced by the latent constructs, we used IBM SPSS Statistics version 23 and computed the Cronbach's alpha coefficient for each scale. To examine the measurement model of the MUSIC Inventory, we conducted confirmatory factor analyses using LISREL 8 (Jöreskog & Sörbom, 1993). To test the first and second hypotheses, we computed Pearson correlation coefficients among the variables. To test the third hypothesis, we examined the structural patterns among the MUSIC model variables, the science identification variable, and the science career goal variable for both the U.S. and Iceland data using LISREL 8 (Jöreskog & Sörbom, 1993); all parameter estimates were reviewed for significance and magnitude in the model.

Results

Hypotheses 1 and 2

All five of the MUSIC model variables were significantly correlated with science identification in both the U.S. and Icelandic samples ($p < .001$; see Table 3). Thus, we confirmed our first hypothesis that the five MUSIC model components would be correlated positively with students' science identification. We also confirmed our second hypothesis for both the U.S. and Icelandic samples, which stated that students' science identification would correlate positively with their science career goals ($p < .001$; see Table 3).

Hypothesis 3

To address Hypothesis 3, we first examined a one-factor measurement model (with only the five MUSIC model constructs) to ensure that they were acceptable for the full

Table 3. Correlations among the study variables.

Variable	1 U.S., IS	2 U.S., IS	3 U.S., IS	4 U.S., IS	5 U.S., IS	6 U.S., IS
1. Empowerment	–					
2. Usefulness	.50, .39	–				
3. Success	.47, .40	.57, .54	–			
4. Interest	.53, .44	.69, .69	.62, .63	–		
5. Caring	.44, .32	.33, .40	.52, .43	.51, .56	–	
6. Identification	.45, .42	.68, .80	.68, .51	.66, .71	.42, .47	–
7. Career goals	.29, .27	.60, .63	.41, .30	.42, .48	.17[a], .30	.52, .66

Note: $p < .001$ for all correlations unless noted otherwise; U.S. = United States; IS = Iceland.
[a]$p < .01$.

structural equation modelling (SEM) analysis. As expected, the inter-correlations among the five MUSIC model latent variables were significantly positive ($p < .001$) for both the U.S. and Icelandic samples. In addition, the pattern coefficients for the individual observed variables associated with each of the five MUSIC components ranged from .57 to .83 for U.S. sample and from .47 to .91 for the Icelandic sample; all of these coefficients were statistically different from zero ($p < .01$). Next, we tested the one-factor measurement model to ensure that the MUSIC model components were distinct. The results for the U.S. data produced an overall χ^2 value of 314.96, $df = 125$, with the goodness-of-fit indices indicating a reasonably good fit to the data, RMSEA = .07, SRMR = .05, NFI = .96, and CFI = .97. The results for the Icelandic data produced an overall χ^2 value of 208.7, $df = 125$, with the goodness-of-fit indices indicating a reasonably good fit to the data, RMSEA = .05, SRMR = .05, NFI = .91, and CFI = .97 (Byrne, 2001; Kline, 2005).

Given that the one-factor measurement model with the five MUSIC model constructs was acceptable for both the U.S. and Icelandic samples, we were able to use SEM to test Hypothesis 3 by examining the relationships among the five components of the MUSIC model, students' science identification, and students' science career goals (as shown in Figures 3 and 4). The results of the U.S. sample indicated an overall model with a χ^2 value of 545.6 ($df = 236$) and fit indices as follows: RMSEA = .06, SRMR = .05, NFI = .96, and CFI = .98. In addition, the results of the Icelandic sample indicated an overall model with a χ^2 value of 431.8 ($df = 236$) and fit indices for the model as follows: RMSEA = .06, SRMR = .05, NFI = .90, and CFI = .95. The results revealed that the hypothesised models for both the U.S. and Icelandic samples fit the data reasonably well (Byrne, 2001; Kline, 2005). Further investigation of the structural patterns in the U.S. model showed that the hypothesised path leading from usefulness to science identification, and the path from success to science identification, were supported by the data ($\beta = .67$, $p < .01$ and $\beta = .32$, $p < .01$, respectively). In addition, science identification had a significant effect on students' science career goals ($\beta = .70$, $p < .01$). Investigation of the structural patterns in the Icelandic data indicated that the hypothesised path leading from usefulness to science identification was supported by the data ($\beta = .78$, $p < .01$). In addition, science identification was significantly related to students' science career goals ($\beta = .75$, $p < .01$).

Discussion

Summary of findings

The purpose of this study was to examine the extent to which students' motivation-related science class perceptions predicted their science identification and career goals. We tested

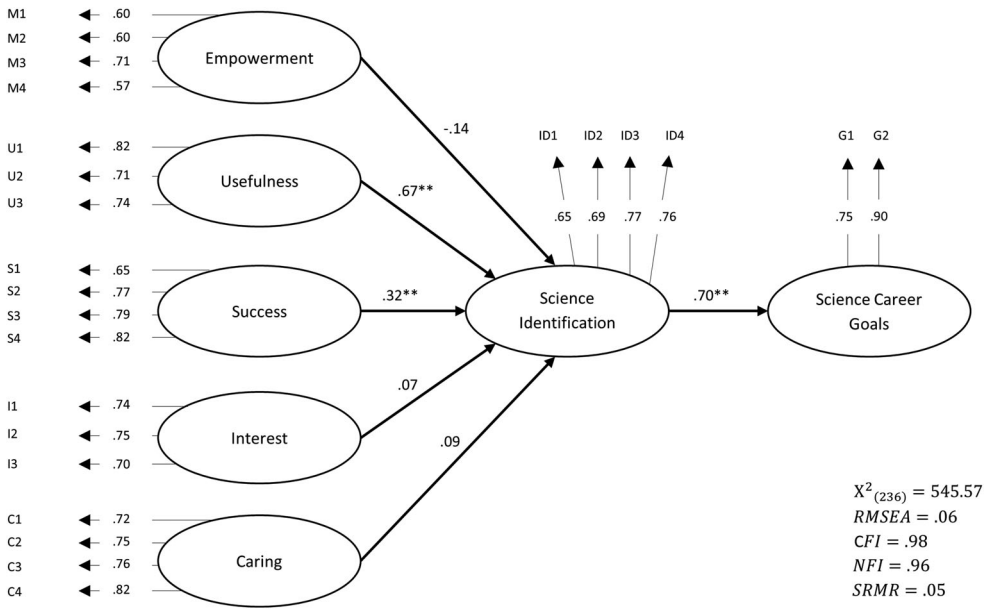

Figure 3. Effects of the MUSIC model components on students' science identification and career goals for U.S. data. $^{**}p < .01$.

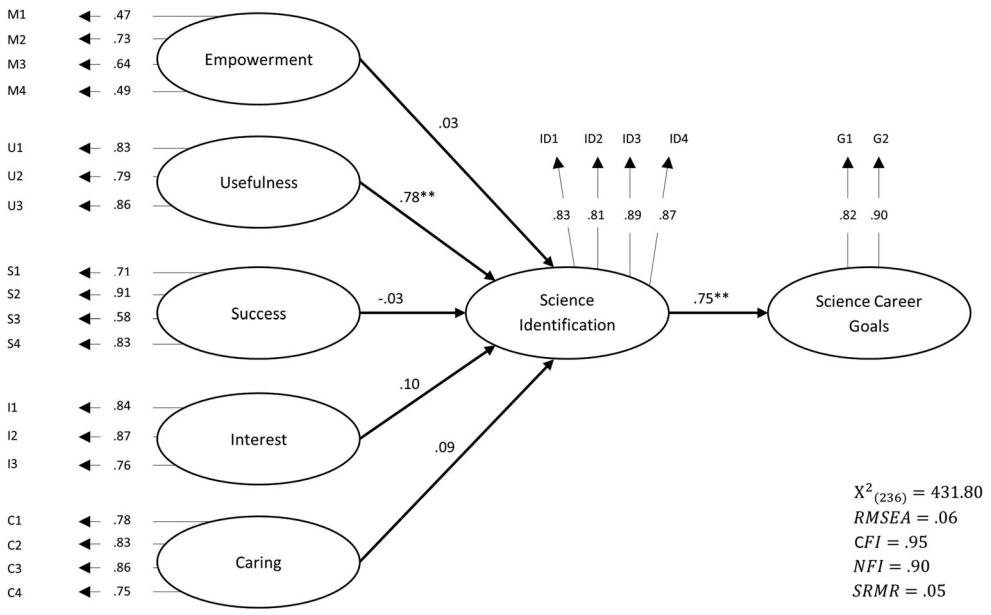

Figure 4. Effects of the MUSIC model components on students' science identification and career goals for Icelandic data. $^{**}p < .01$.

three hypotheses in U.S. and Icelandic samples, and confirmed all three hypotheses through the use of correlational analyses and SEM. For our first hypothesis, we predicted that the five MUSIC model components would correlate positively with students' science identification. We confirmed this hypothesis by documenting that empowerment, usefulness, success, interest, and caring were all correlated positively with science identification ($p < .001$) for both the U.S. and Icelandic samples. We also confirmed our second hypothesis by showing that science identification was positively correlated with students' career goals ($p < .001$) for both the U.S. and Icelandic samples.

Given these findings, it was reasonable to include all of these variables in one model for our third hypothesis: students' perceptions of the MUSIC model components in science class will predict their science identification, which in turn will predict their science career goals. The hypothesised model fit the data reasonably well; however, only usefulness and success in the U.S. sample, and only usefulness in the Icelandic sample, predicted science identification when the career goals variable was included in the model. Thus, although we confirmed our third hypothesis, all of the paths were not statistically significant, as we had expected. These results indicate that usefulness and success in the U.S. sample were stronger predictors of science identification and career goals than the other MUSIC model components (i.e. empowerment, interest, and caring). This finding indicates that, although the MUSIC model components are related to students' science identification, usefulness (and success in the U.S. sample) was the best predictor of both science identification and career goals.

In the remainder of this section, we discuss the theoretical and practical implications of these findings. Because the results for the U.S. and Icelandic samples are very similar, we discuss the results of these samples together rather than independently.

Theoretical implications

Our findings contribute to theory by providing further evidence that the MUSIC model components are related to students' science identification and that science identification is related to career goals. These results are consistent with other studies that have reported similar positive correlations for university engineering students (Jones et al., 2014, 2016), middle school science students (Aschbacher et al., 2014), and high school science students (Krogh & Andersen, 2013). Furthermore, these findings generalise across two cultures (American and Icelandic), which indicates that they may generalise to other cultures as well. Because these two cultures are similar in many ways, it could be useful to test these hypotheses in cultures that are not quite as similar. Future studies could also examine these relationships in other domains (e.g. mathematics, social studies) and grade levels to provide further evidence of the generalisability of the domain identification model presented in Osborne and Jones (2011).

In the full models tested for both the U.S. and Icelandic samples, students' perceptions of the usefulness of their science classwork was the strongest predictor of their science identification when career goals was also included in the model. It is logical that there is consistency between students' perceptions of science class usefulness, science identification, and science career goals because they all relate to students' goals. In science class, students form their perceptions of the usefulness of the class, which then affects their level of science identification, which then affects their science career goals.

Domain identification theory (Osborne & Jones, 2011) predicts that students who find consistencies between the usefulness of the class and their identification and career goals will put forth more effort in science class, be more likely to persist at challenges, and choose science activities and courses in the future. The theory also predicts that this process is cyclical; therefore, it is reasonable to expect that students' science career goals then cycle back and affect their perceptions of the usefulness of the class and their science identification. Thus, the science classwork can support students' science identification and career goals, which then can continue to support their motivation and engagement in science classwork.

In contrast, students who find inconsistencies between the class usefulness and their identification and career goals will put forth less effort in science class, be less likely to persist at challenges, and not choose science activities and courses in the future. In this scenario, students' science identification and career goals lead to a lack of student motivation and lower engagement in science classwork. Of course, the domain identification model also acknowledges that other factors also affect students' motivation, such as their group membership (race, gender, social class); family, peers, and community environment; school climate; and formal and informal educational experiences (including perceptions of empowerment, success, interest, and caring). Consequently, it is possible for a student to be motivated and engaged in science classwork for reasons besides their science identification and career goals.

The fact that all five MUSIC model components did not predict students' science identification in the full model, contrasts with the fact that all five MUSIC model components predicted undergraduate engineering students' engineering identification in one study (Jones et al., 2014) and four of the MUSIC model components in another study (Jones et al., 2016). The differences among these studies raises some interesting theoretical questions. For example, are the perceptions of some MUSIC model components more predictive of students' domain identification at some ages than others? Maybe usefulness and success are more predictive of domain identification in grades five, six, and seven (as documented in the U.S. sample in the present study) and empowerment, interest, and caring become more important at the college level (as documented by Jones et al., 2016). Or, maybe different perceptions are important in different domains (e.g. science versus engineering), regardless of age.

Practical teaching implications

The positive correlations between the MUSIC model components and domain identification indicate that it may be possible to increase students' science identification by increasing students' perceptions of the MUSIC components in science class. Because the MUSIC model was developed based on practical teaching strategies (Jones, 2009, 2015), it is possible for teachers to increase students' perceptions of empowerment, usefulness, success, interest, and caring by designing instruction consistent with the MUSIC model. Further research is needed to examine which strategies are most effective to increase students' levels of domain identification within particular domains and grade levels.

To increase the likelihood that students will choose careers in science, the results of our SEM analyses suggest that it might be most productive for teachers to target the usefulness

and success components of the MUSIC model. However, even though students' perceptions of empowerment, interest, and caring were not statistically significantly related to science identification and career goals in the complete model, it does not mean that they are not important for teachers to consider to increase students' engagement and academic outcomes. We documented positive correlations between all of the MUSIC model components, which indicates that empowerment, interest, and caring may support students' perceptions of usefulness and success. Or, empowerment, interest, and caring may support students' classroom motivation in ways that usefulness and success do not. Future research could examine how these five MUSIC model components interact to affect students' science identification and career goals.

Because students' perceptions of usefulness and success were significantly related to science identification and career goals in the full model, we end this section with a few examples of how teachers can intentionally design instruction to increase students' perceptions of usefulness and success in a science class. Students with high perceptions of science *usefulness* in a class believe that their science class work is useful in their lives and/or for their future. Teachers can foster science class usefulness perceptions by explicitly stating how what they are doing in class relates to students' lives or to their future (e.g. Mehalik et al., 2008; Milner et al., 2011; Nieswandt & Shanahan, 2008). Other ways to increase perceptions of usefulness include designing activities that allow students to see the usefulness through their participation in the activities. For example, teachers can complement traditional instruction with authentic learning experiences that incorporate real-world tasks and objectives (e.g. laboratory work, design-based learning; Doppelt et al., 2008; Mehalik et al., 2008; Milner et al., 2011; Reynolds et al., 2009).

Instead of teachers telling or showing students why the content is useful to them, other approaches have allowed students to write or discuss how the content is useful to them. In one intervention study, students in a ninth grade science class who had low expectations for success in science at the beginning of the semester were more likely to be interested in science and had higher grades at the end of the semester when they wrote essays (Hulleman & Harackiewicz, 2009). For the essays, the students were prompted every 3 or 4 weeks to write about how the content was useful to their lives. In another study that used a quasi-experimental intervention, the instructor divided students in the experimental group into teams of three or four and asked students to discuss their perceptions and feelings about the course, how the course related to their short- and/or long-term goals, and topics that interested them in the course (Mc Ginley & Jones, 2014). Compared to the students in the control group who did not discuss these topics, students in the experimental group rated the course as more interesting (i.e. important and valuable) to them. These two interventions show how teachers can affect students' interest and identification in a subject by having them write or discuss how the content is useful to their personal lives and goals.

Students with high perceptions of *success* believe that they can succeed at their science class work. Bandura (1997) identified four factors that can affect students' perceptions of future success in an activity (i.e. self-efficacy for an activity): mastery experiences, vicarious experiences, social persuasions, and physiological and affective states. Teachers can support students' mastery experiences by designing activities that challenge students yet allow them to succeed if they put forth the required effort. Success at challenging activities can increase students' perceptions that they will be more likely to succeed at these activities in the future. Simply providing students with positive experiences and

opportunities in which they can be successful in science can be beneficial to their positive self-perceptions (e.g. Simpkins et al., 2006). Teachers can also use vicarious experiences by allowing students to show each other their successes and to model successful experiences. For example, Berger and Hänze (2009) found that, when students played the role of 'expert' to their peers, such as when engaging in 'Jigsaw' cooperative learning activities, students held more positive science competence perceptions. Teachers can use social persuasions by giving students verbal and written feedback about their capabilities that is honest yet demonstrates the teacher's belief that the student can be successful. Reducing students' anxiety is one way that teachers can promote positive physiological and affective states. Teachers can reduce anxiety by using strategies such as communicating clear and realistic expectations of students, assessing students in relation to some criterion instead of comparing students normatively, and allowing students to revise their work if necessary to correct errors, among others (Ormrod & Jones, 2018).

Conclusion

In two different cultures (American and Icelandic), middle school students' perceptions of the MUSIC model components in their science class were related to their science identification and career goals. However, students are more likely to consider a science career when they believe that their science class is useful and that they can succeed in the class. These findings suggest that it may be possible for teachers to focus on some of the MUSIC model components to foster students' science identification and the likelihood that they will choose science-related careers. Our results are important because they provide evidence for the theoretical connection between classroom teaching strategies and students' career goals.

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