Not Just "Rocks for Jocks": Who Are Introductory Geology Students and Why Are They Here?

Lisa A. Gilbert,[1,a] Jennifer Stempien,[2] David A. McConnell,[3] David A. Budd,[2] Katrien J. van der Hoeven Kraft,[4] Ann Bykerk-Kauffman,[5] Megan H. Jones,[6] Catharine C. Knight,[7] Ronald K. Matheney,[8] Dexter Perkins,[8] and Karl R. Wirth[9]

ABSTRACT

Do students really enroll in Introductory Geology because they think it is "rocks for jocks"? In this study, we examine the widely held assumption that students view geology as a qualitative and remedial option for fulfilling a general education requirement. We present the first quantitative characterization of a large number of Introductory Geology students, their demographic characteristics and motivations at the start of the course, and their reasons for enrolling. More than 1,000 undergraduate students from seven institutions across the U.S. participated in this study, providing demographic information and responses to the Motivated Strategies for Learning Questionnaire. Students taking Introductory Geology either to fulfill a general education requirement (72% of the survey population) or because they thought it would be easy (19%) had relatively low motivation. The youngest students (18 or 19 years, 62% of the survey population) and those who had not declared a major or were planning a nonscience major (79%) also had relatively low motivation. In contrast, students taking the course for a major or minor (26%), because of prior interest in geology (31%), or because of interest in the interactions between humans and the environment (15%) had relatively high motivation. The differences in motivation we identify have important implications for Introductory Geology instructors, particularly those teaching large-enrollment courses, and validate the need for understanding student characteristics when designing course goals and selecting instructional strategies. © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/12-287.1]

Key words: affective domain, geoscience education, motivation, MSLQ

INTRODUCTION

Geology is commonly viewed by undergraduate students as a qualitative and remedial science (e.g., Wenner et al., 2009; Wagner, 2010). This view might be fueled by limited exposure to geology in high school (Holbrook, 1997; Van Norden, 2002), and the lack of an advanced placement course in geology (Willyard, 2008; Gonzales and Keane, 2010). As of 2009, a high school geology or Earth science course was required in only seven states and recommended in only 24 states (American Geological Institute, 2009). Further, geology is rarely a prerequisite for other science majors or medical school (unlike biology, chemistry, and physics, or some combination thereof), although it is sometimes required for elementary education majors (e.g., Wagner, 2010). Within our own geoscience community the refrain, "rocks for jocks" is a common pejorative used in articles and abstracts (Thompson, 1994; Van Norden, 2002; Underwood, 2008; Willyard, 2008; Kraft and Husman, 2009; Van Norden and Ingersoll, 2011), a book review (Scott, 2003), and a published acceptance speech for an award (Bodnar, 2009).

Within this overall negative context (perceived or otherwise), the purpose of this paper is to empirically address the following questions: (1) Who are the students taking Introductory Geology? and (2) Why are they enrolling?

In characterizing the students (Who are they?), we consider both (1) basic demographic characteristics (gender, age, and race/ethnicity) and (2) interest and academic experience information (prior coursework, major, and stated interest in science). To examine students' reasons for enrolling in Introductory Geology (Why are they here?), we allowed students to offer more than one answer, acknowledging that students often choose to take a specific introductory science course based on an array of reasons. Knowledge of student characteristics and reasons for enrolling in introductory geology can guide instructor efforts in the design of effective course materials and selection of appropriate teaching strategies.

Our approach to these questions is to focus on motivation, defined as the process by which goal-directed activities are initiated and sustained (Schunk et al., 2008). Motivation should not only speak to why students enroll, but also once enrolled, motivation should also affect their chances for success. Many college geoscience instructors rate motivation as the most important driver for student learning

Received 17 January 2012; revised 15 June 2012; accepted 6 July 2012; published online 6 November 2012.

[1]Maritime Studies Program of Williams College and Mystic Seaport, Mystic, Connecticut 06355, USA
[2]Department of Geology, Colorado University, Boulder, Colorado 80309, USA
[3]Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina 27695, USA
[4]Department of Physical Science, Mesa Community College, Mesa, Arizona 85202, USA
[5]Department of Geological and Environmental Sciences, California State University, Chico, Chico, California 95929, USA
[6]Department of Geology, North Hennepin Community College, Brooklyn Park, Minnesota 55445, USA
[7]Department of Education, University of Akron, Akron, Ohio 44325, USA
[8]Department of Geology, University of North Dakota, Grand Forks, North Dakota 58202, USA
[9]Department of Geology, Macalester College, St. Paul, Minnesota 55105, USA
[a]Author to whom correspondence should be addressed. Electronic mail: lgilbert@williams.edu. Tel.: 860-572-5359. Fax: 860-572-5329

(Markley et al., 2009). Perry et al. (2007) showed a profound link between students' feeling of ''control'' and learning. Covington (2007), Pekrun (2007), and Zusho et al. (2007) demonstrated that student motivation can have more significant influences on college student learning (reflected by grades and concept inventories) than does student ability, as measured by standardized test results. Interest is a strong predictor of students' choice to enroll in an additional content course, even stronger than academic performance (Harackewicz et al., 2000), and students' choices of major and ultimately of career, are strongly influenced by their self-efficacy beliefs (Hackett, 1995). Further, educational psychology studies have demonstrated that certain positive motivation characteristics are a necessary precondition for learning (Perrier and Nsengiyumva, 2003; Zusho et al., 2003).

These prior results indicate that efforts to improve learning about the Earth and increase the numbers of geoscience majors would be aided by placing more attention on student motivation. The importance of motivation has been well studied in a variety of educational levels, content areas, and educational settings (e.g., Pintrich and DeGroot, 1990; Pintrich, 2003; Schunk et al., 2008; van der Hoeven Kraft et al., 2011). In this study, we measured value and expectancy—two components of motivation that commonly impact student engagement and performance (Pintrich and Zusho, 2007)—at the start of Introductory Geology. Value includes goal orientation (both intrinsic and extrinsic) as well as the student's evaluation of the interest, importance, or usefulness of the course (task value). Measures of expectancy include both the student's belief that learning and the course outcome are under the control of the student (control of learning beliefs), and that a student believes she/he has the skills to be successful in the course and assignments (self-efficacy for learning and performance).

Many assessments have been used to measure motivation, including the Academic Motivation Scale (Vallerand et al., 1992), the Intrinsic Motivation Inventory (Ryan and Deci, 2000), the Conceptions of Science Survey (Libarkin, 2001), the Study Process Questionnaire (Biggs et al., 2001), the Learning and Study Skills Inventory (Cano, 2006), and the Self-Efficacy Questionnaire (Bandura, 2006). For this study, we selected the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) (Table I). The MSLQ has been validated and widely used as an assessment tool in a variety of settings and disciplines (e.g., Pintrich et al., 1993; Birenbaum, 1997; Husman et al., 2004; Dahl et al., 2005; Duncan and McKeachie, 2005; Richardson, 2007; Artino, 2009; Matuga, 2009).

METHODS
Data Collection

During the 2009–2010 academic year, a total of 1,057 students agreed to participate in the study and provided data (two completed surveys). Participating students were enrolled in Introductory Geology at one of seven postsecondary institutions from across the U.S.: California State University at Chico (CSUC; $n = 220$, 21% of total study population), Macalester College (MC; $n = 49$, 5%), North Carolina State University (NCSU; $n = 166$, 16%), North Hennepin Community College (NHCC; $n = 47$, 4%), Scottsdale Community College (SCC; $n = 66$, 6%), University of Colorado–Boulder (UCB; $n = 270$, 26%), and University of North Dakota (UND; $n = 239$, 23%). All of the courses were an introductory physical geology course except one of the four courses at UND, which was an introductory environmental geology course. The university classes (CSUC, NCSU, UCB, and UND) typically enrolled 60–160 students each. The community colleges (NHCC and SCC) and liberal arts college (MC) classes enrolled fewer than 30 students each.

In the third week of the course, participating students completed two surveys online, a demographic survey (Supplement A: Demographic Data; available at http://dx.doi.org/10.5408/12-287s1) and the MSLQ. For the demographic survey, questions included basic demographic information such as gender, age, and race/ethnicity, as well as interest and academic experience in science and reasons for enrolling in the course. On the MSLQ, students rated themselves on a 7-point Likert-type scale, from 1 (''not at all true of me'') to 7 (''very true of me'') for a variety of statements as each applied to their Introductory Geology (Pintrich et al., 1991).

Calculation of Motivation Scores

Individual student responses for all questions in an MSLQ subscale, e.g., task value, (Table I) were averaged to obtain a student's score for that specific subscale. Individual student subscale scores were then organized as a function of demographic variables to assess variations of motivations between groups, e.g., the intrinsic goal orientation of different age groups) (Table II). Students' overall MSLQ ''motivation'' scores were calculated as the mean MSLQ results from intrinsic goal orientation, task value, control of

TABLE I: Components of selected subscales of the Motivated Strategies for Learning Questionnaire.

Motivation Scale	Subscale[1]
Value	Intrinsic goal orientation (4)—the student engages in the course because of curiosity about the subject or a desire to master the material
	Extrinsic goal orientation (4)—student's view that s/he is participating in the course for grades, performance, or other evaluation
	Task value (6)—student's evaluation of the interest, importance or usefulness of the course
Expectancy	Control of learning beliefs (4)—the student believes that s/he controls learning so that course outcomes are dependent on their own efforts
	Self-efficacy for learning and performance (8)—the student believes that s/he has the skills to complete the course and that s/he expects to be successful on class assignments

[1]The number in parentheses indicates the number of survey items per subscale.

TABLE II: Means (± standard deviations) of MSLQ results for overall motivation and for the five subscales listed in Table I.[1]

Variable	Category	*n*	Motivation	Intrinsic	Extrinsic	Task value	Control beliefs	Self-efficacy
Basic demographic								
Gender	Male	518	*4.90 ± 0.87*	*4.51 ± 1.02*	**5.16 ± 1.14**	*4.64 ± 1.17*	*5.26 ± 1.03*	*5.20 ± 1.04*
	Female	539	*4.85 ± 0.92*	*4.48 ± 1.12*	**5.38 ± 1.13**	*4.67 ± 1.23*	*5.22 ± 0.98*	*5.05 ± 1.06*
Age (yrs)	18–19	651	**4.77 ± 0.88**	*4.39 ± 1.09*	*5.35 ± 1.11*	*4.56 ± 1.18*	*5.16 ± 1.00*	**5.01 ± 1.02**
	20–21	262	**4.93 ± 0.89**	*4.59 ± 1.00*	*5.20 ± 1.14*	*4.70 ± 1.23*	*5.23 ± 1.01*	**5.21 ± 1.05**
	22–25	83	**5.02 ± 0.84**	*4.55 ± 1.12*	*5.06 ± 1.24*	*4.68 ± 1.14*	*5.54 ± 0.93*	**5.33 ± 1.09**
	>25	52	**5.52 ± 0.80**	*5.18 ± 0.89*	*4.93 ± 1.28*	*5.51 ± 1.00*	*5.75 ± 0.98*	**5.66 ± 1.05**
Race/ethnicity	Asian	36	*4.90 ± 0.80*	*4.57 ± 0.85*	*5.63 ± 1.04*	*4.79 ± 1.10*	*5.30 ± 1.07*	*4.93 ± 0.95*
	Caucasian	866	*4.89 ± 0.90*	*4.50 ± 1.08*	*5.24 ± 1.14*	*4.65 ± 1.19*	*5.26 ± 0.99*	*5.15 ± 1.06*
	Underrepresented	155	*4.80 ± 0.89*	*4.45 ± 1.09*	*5.35 ± 1.15*	*4.62 ± 1.25*	*5.11 ± 1.05*	*5.01 ± 1.02*
Interest and experience								
Major	Non-STEM	433	**4.75 ± 0.89**	**4.33 ± 1.09**	*5.24 ± 1.15*	**4.47 ± 1.20**	**5.12 ± 1.01**	**5.06 ± 1.05**
	Undecided	405	**4.79 ± 0.88**	**4.43 ± 1.05**	*5.30 ± 1.15*	**4.58 ± 1.20**	**5.21 ± 1.00**	**4.96 ± 1.03**
	STEM	219	**5.28 ± 0.78**	**4.92 ± 0.97**	*5.28 ± 1.10*	**5.16 ± 1.05**	**5.54 ± 0.94**	**5.53 ± 0.98**
Likelihood of natural science major	None	436	**4.54 ± 0.89**	**4.12 ± 1.08**	*5.20 ± 1.19*	**4.08 ± 1.15**	***5.06 ± 1.07***	*4.89 ± 1.12*
	Low	366	**4.92 ± 0.80**	**4.55 ± 0.98**	*5.30 ± 1.10*	**4.74 ± 1.02**	***5.26 ± 0.95***	*5.15 ± 0.94*
	Some	132	**5.23 ± 0.73**	**4.96 ± 0.87**	*5.45 ± 1.02*	**5.42 ± 0.94**	***5.37 ± 0.89***	*5.18 ± 0.88*
	High	123	**5.56 ± 0.73**	**5.17 ± 0.93**	*5.23 ± 1.18*	**5.62 ± 0.93**	***5.68 ± 0.88***	*5.77 ± 0.96*
Science interest	None	56	**3.90 ± 0.99**	**3.71 ± 1.20**	*5.06 ± 1.26*	**3.27 ± 1.14**	**4.42 ± 1.13**	**4.20 ± 1.22**
	Low	205	**4.27 ± 0.77**	**3.76 ± 0.91**	*5.27 ± 1.10*	**3.80 ± 0.94**	**4.91 ± 1.08**	**4.61 ± 1.03**
	Some	558	**4.88 ± 0.73**	**4.50 ± 0.93**	*5.25 ± 1.16*	**4.68 ± 1.00**	**5.24 ± 0.92**	**5.12 ± 0.93**
	High	238	**5.62 ± 0.70**	**5.30 ± 0.87**	*5.37 ± 1.10*	**5.66 ± 0.94**	**5.73 ± 0.85**	**5.78 ± 0.87**
High school science courses	0–3	463	**4.72 ± 0.96**	**4.33 ± 1.13**	*5.28 ± 1.17*	**4.50 ± 1.24**	**5.12 ± 1.05**	**4.95 ± 1.09**
	>3	594	**5.00 ± 0.82**	**4.62 ± 1.00**	*5.27 ± 1.12*	**4.78 ± 1.15**	**5.34 ± 0.96**	**5.25 ± 0.99**
College STEM courses	0	247	**4.85 ± 0.84**	**4.49 ± 1.03**	*5.34 ± 1.13*	**4.70 ± 1.14**	**5.22 ± 0.96**	**5.00 ± 1.04**
	1–3	513	**4.77 ± 0.91**	**4.36 ± 1.09**	*5.28 ± 1.15*	**4.50 ± 1.22**	**5.18 ± 1.03**	**5.04 ± 1.03**
	4–6	175	**4.95 ± 0.87**	**4.63 ± 0.98**	*5.29 ± 1.10*	**4.73 ± 1.17**	**5.23 ± 0.99**	**5.20 ± 1.01**
	>6	122	**5.28 ± 0.83**	**4.86 ± 1.08**	*5.07 ± 1.17*	**5.11 ± 1.12**	**5.55 ± 0.94**	**5.59 ± 1.06**
Reason for taking the course								
General education requirement	No	292	**5.24 ± 0.84**	**4.88 ± 0.98**	*5.25 ± 1.16*	**5.18 ± 1.08**	**5.51 ± 0.96**	**5.38 ± 1.03**
	Yes	765	**4.74 ± 0.87**	**4.35 ± 1.07**	*5.28 ± 1.13*	**4.45 ± 1.18**	**5.14 ± 1.01**	**5.02 ± 1.04**
Major/minor requirement	No	779	**4.08 ± 0.89**	**4.42 ± 1.07**	*5.25 ± 1.16*	**4.54 ± 1.21**	**5.19 ± 1.00**	**5.06 ± 1.04**
	Yes	278	**5.09 ± 0.87**	**4.70 ± 1.04**	*5.33 ± 1.09*	**4.98 ± 1.10**	**5.39 ± 1.00**	**5.29 ± 1.05**
Easy course	No	861	**4.93 ± 0.90**	**4.56 ± 1.07**	**5.23 ± 1.13**	**4.73 ± 1.20**	*5.27 ± 1.01*	**5.15 ± 1.04**
	Yes	196	**4.64 ± 0.83**	**4.19 ± 1.01**	**5.43 ± 1.18**	**4.32 ± 1.12**	*5.12 ± 0.98*	**4.96 ± 1.08**
Prior geology interest	No	734	**4.67 ± 0.88**	**4.28 ± 1.05**	*5.28 ± 1.12*	**4.32 ± 1.14**	**5.11 ± 1.03**	**4.96 ± 1.07**
	Yes	323	**5.35 ± 0.73**	**4.98 ± 0.94**	*5.24 ± 1.18*	**5.41 ± 0.94**	**5.54 ± 0.89**	**5.48 ± 0.89**
Human/environment interest	No	894	**4.77 ± 0.88**	**4.36 ± 1.04**	**5.30 ± 1.12**	**4.49 ± 1.17**	**5.18 ± 1.02**	**5.05 ± 1.06**
	Yes	163	**5.45 ± 0.73**	**5.20 ± 0.93**	**5.09 ± 1.21**	**5.57 ± 0.87**	**5.55 ± 0.85**	**5.47 ± 0.91**

[1]Bold numbers indicate statistically significant differences between groups; see Table III for details. Italicized numbers indicate no significant difference between the groups.

learning beliefs, and self-efficacy (Table II). Extrinsic goal orientation was not included in our calculation of overall motivation because higher extrinsic goal orientation has been related to lower interest, value, and self-efficacy (Ryan and Connell, 1989), and has a small effect size (Cohen's d $\sim$0.2; Coladarci et al., 2008) for the three variables for which it is significant (Tables II and III).

Statistical Analysis

For the first step in our analysis, we examined the distribution of student demographics and reasons for enrolling. We used chi-square goodness-of-fits tests to determine if observed distributions varied significantly from assumed randomly distributed populations or institution-wide demographic information (compiled from institutional Web sites).

Second, to identify significant differences in motivation between multiple groups within a demographic variable, we used the nonparametric Kruskal–Wallis test (Kruskal and Wallis, 1952). We did not use more commonly known parametric statistical methods, such as analysis of variance (ANOVA) because of unequal sample sizes and variance for some demographic groups (see Fig. 1), which violated assumptions of such tests. The Kruskal–Wallis test is analogous to a single-factor ANOVA but completes the analysis of equality for the medians of several groups through the use of ranks. This approach makes the Kruskal–Wallis test desirable when the samples are not derived from normal populations (Krutchkoff, 1988). Similar to a single-factor ANOVA, the Kruskal–Wallis test only identifies if significant differences are present among multiple groups. Where there were only two possible categories (e.g., "yes" or "no" for a reason for enrolling), a paired Student's t-test was applied in place of the above two steps.

Third, for pair-wise comparisons that yielded a significant difference, we calculated the effect sizes with Cohen's d by using the pooled standard deviations (Coladarci et al., 2008). Effect sizes indicate whether the results are more than statistically significant, rather than if they are statistically meaningful.

Finally, when considering the different subscales of motivation together, we used the Holm–Bonferroni method (Holm, 1979). This method is used to limit the statistical probability of finding a statistically meaningful result simply because of the high number of variables. Specifically, we took the results from the Kruskal–Wallis tests (second step above), and ordered the p values from smallest to largest. Then, rather than using $\alpha = 0.05$ to reject or accept each null hypothesis, we used $\alpha = 0.01$ (with the smallest p value), 0.02, 0.03, 0.04, and 0.05 (with the largest p value). This final step in our analysis establishes a greater confidence in those rejected hypotheses with p values between 0.01 and 0.05 (Table III).

Analyses were completed with SAS 9.2 and MATLAB 7.9.

Confirmation of the MSLQ for Introductory Geology

Pintrich et al. (1991) statistically assessed the validity of the MSLQ to capture motivations and learning strategies by using a heterogeneous student population that included science and nonscience disciplines and varying levels of education. We replicated the original analysis by Pintrich et al. to ensure the survey was appropriate for an undergraduate-only population for Introductory Geology. Confirmatory factor analyses using the conventional maximum likelihood method were completed on the same models diagrammed by Pintrich et al. (1991, 1993). The analysis identified how well the individual statements are associated with each of the proposed subscales. We used the same three parameters originally used by Pintrich et al. (1991) for evaluation: (1) λx values to indicate how strongly an observed variable (e.g., individual statement) loads onto a latent variable (e.g., MSLQ subscale), (2) several goodness-of-fit statistics, and (3) Cronbach αs for reliability and internal consistency. The λx values from our data were 0.73 on average and were comparable or higher than values originally computed by Pintrich et al. (their average was 0.68). The goodness-of-fit statistical results using our data also matched ranges computed by Pintrich et al. (1991). Last, our Cronbach αs (0.62–0.93) were comparable or better than values computed (0.52–0.93) by Pintrich et al. (1991) when computed for each subscale using all the items within a subscale. Together these measures demonstrate the applicability of the MSLQ to our data.

RESULTS

Basic Demographics

In geosciences, as in all science, technology, engineering, and mathematics (STEM) fields, efforts have been made in recent decades to increase diversity and retain women, minority students, and other under-represented groups (e.g., Lee, 1991; George et al., 2001; Burke and Mattis, 2007). Below, we summarize the basic demographic characteristics of the Introductory Geology students surveyed.

Gender

Students participating in the study were 51% female ($n = 539$) and 49% male ($n = 518$) (Fig. 1). Although gender percentages varied among institutions, women constituted more than 40% of participating students in every Introductory Geology class. Only two institutions had gender ratios that varied significantly from 50:50: UCB ($\chi^2 = 4.28$, df = 1, $p = 0.038$) and UND ($\chi^2 = 5.73$, df = 1, $p = 0.017$). When compared with the ratio of female to male students at a given institution, only UCB was statistically significant ($\chi^2 = 9.16$, df = 1, $p = 0.0025$) during spring 2010, with a higher proportion of women in Introductory Geology than what would be expected based on university demographics. The lower percentage of women in Introductory Geology in UND is not statistically different from the overall percentage of female students at the institution ($\chi^2 = 3.05$, df = 1, $p = 0.08$).

Race/Ethnicity

The majority of the students that participated in the study identified themselves as Caucasian (81%, $n = 866$) (Fig. 1). Only 15% ($n = 155$) of the participants identified themselves as from under-represented ethnicities, which included Hispanic of Any Race, Black or African American, American Indian or Alaskan, Native Asian, Native Hawaiian or Other Pacific Islander, and 3% identified as Asian ($n = 36$). Although the relative proportions of students in each ethnic group varied from institution to institution, Caucasian students were consistently 75% or more of the

TABLE III: Additional statistics.[1]

Variable	Category	Motivation			Intrinsic goal orientation		
Demographic							
Gender	df = 1,055	*$t = 0.84$*	*$p = 0.40$*		*$t = 0.40$*	*$p = 0.69$*	
Age (yrs)	df = 3	$\chi^2 = 36.92$	$p < 0.0001$		*$\chi^2 = 1.94$*	*$p = 0.38$*	
	18–19 and 20–21		$p = 0.016$	$d = -0.17$			
	18–19 and 22–25		$p = 0.037$	$d = -0.73$			
	18–19 and >25		$p < 0.0001$	$d = -1.30$			
	20–21 and 22–25		*$p = 0.64$*				
	20–21 and >25		$p < 0.0001$	$d = -1.06$			
	22–25 and >25		$p = 0.00061$	$d = -1.20$			
Race/ethnicity	df = 2	*$\chi^2 = 1.9215$*	*$p = 0.3826$*		*$\chi^2 = 0.46$*	*$p = 0.79$*	
Interest and experience							
Major	df = 2	$\chi^2 = 56.69$	$p < 0.0001$		$\chi^2 = 44.56$	$p < 0.0001$	
	Non-STEM and undecided		*$p = 0.36$*			*$p = 0.19$*	
	Non-STEM and STEM		$p < 0.0001$	$d = -1.11$		$p < 0.0001$	$d = -0.56$
	Undecided and STEM		$p < 0.0001$	$d = -1.01$		$p < 0.0001$	$d = -0.48$
Likelihood of a natural science major	df = 3	$\chi^2 = 17.04$	$p < 0.0001$		$\chi^2 = 25.16$	$p < 0.0001$	
	None and low		$p < 0.0001$	$d = -0.45$		$p < 0.0001$	$d = -0.42$
	None and some		$p < 0.0001$	$d = -1.30$		$p < 0.0001$	$d = -0.82$
	None and high		$p < 0.0001$	$d = -1.68$		$p < 0.0001$	$d = -0.82$
	Low and some		$p < 0.0001$	$d = -0.89$		$p < 0.0001$	$d = -0.44$
	Low and high		$p < 0.0001$	$d = -1.30$		$p < 0.0001$	$d = -0.65$
	Some and high		$p = 0.00062$	$d = -0.81$		*$p = 0.06$*	
Science interest	df = 3	$\chi^2 = 271.90$	$p < 0.0001$		$\chi^2 = 241.57$	$p < 0.0001$	
	None and low		$p = 0.014$	$d = -0.45$		*$p = 0.62$*	
	None and some		$p < 0.0001$	$d = -1.56$		$p < 0.0001$	$d = -0.82$
	None and high		$p < 0.0001$	$d = -2.49$		$p < 0.0001$	$d = -1.68$
	Low and some		$p < 0.0001$	$d = -1.53$		$p < 0.0001$	$d = -0.80$
	Low and high		$p < 0.0001$	$d = -2.54$		$p < 0.0001$	$d = -1.73$
	Some and high		$p < 0.0001$	$d = -1.56$		$p < 0.0001$	$d = -0.88$
High school science	df = 1,055	$t = -5.05$	$p < 0.0001$	$d = -0.31$	$t = -4.54$	$p < 0.0001$	$d = -0.28$
College STEM courses	df = 3	$\chi^2 = 28.71$	$p < 0.0001$		$\chi^2 = 23.98$	$p < 0.0001$	
	0 and 1–3		*$p = 0.18$*			*$p = 0.10$*	
	0 and 4–6		*$p = 0.36$*			*$p = 0.27$*	
	0 and >6		$p < 0.0001$	$d = -0.94$		$p = 0.006$	$d = -0.14$
	1–3 and 4–6		$p = 0.034$	$d = -0.66$		$p = 0.007$	$d = -0.26$
	1–3 and >6		$p < 0.0001$	$d = -1.03$		$p < 0.0001$	$d = -0.46$
	4–6 and >6		$p = 0.0031$	$d = -0.76$		*$p = 0.09$*	
Reason for taking the course							
General education requirement	df = 1,055	$t = -8.36$	$p < 0.0001$	$d = 0.58$	$t = -7.39$	$p < 0.0001$	$d = 0.51$
Major/minor requirement	df = 1,055	$t = 4.64$	$p < 0.0001$	$d = -1.14$	$t = 3.68$	$p = 0.0002$	$d = -0.26$
Easy course	df = 1,055	$t = -4.04$	$p = 0.0001$	$d = 0.33$	$t = -4.49$	$p < 0.0001$	$d = 0.36$
Prior geology interest	df = 1,055	$t = 12.30$	$p < 0.0001$	$d = -0.82$	$t = 10.17$	$p < 0.0001$	$d = -0.68$
Human/environment interaction	df = 1,055	$t = 9.26$	$p < 0.0001$	$d = -0.79$	$t = 9.56$	$p < 0.0001$	$d = -0.81$

[1]Bold numbers indicate statistically significant differences between groups; italicized numbers indicate no significant difference between the groups either because $p > 0.05$, or for p values between 0.01 and 0.05 failed the Holm's–Bonferroni test (numbers italicized and with superscripted +). Cohen's d is not listed for comparisons with no significant difference (Cohen's d is negative if the second group had a significantly higher mean than the first). Pairwise comparisons were not done if the Kruskal–Wallis test showed no significant difference between any of the groups (blank squares). t = Student's t-test statistic, χ^2 = chi-squared statistic, d = Cohen's d, df = degrees of freedom.

TABLE III: Extended.

Extrinsic goal orientation			Task value			Control beliefs			Self-efficacy		
Demographic											
$t = -3.16$	$p = 0.0016$	$d = -0.19$	$t = -0.33$	$p = 0.7427$		$t = 0.54$	$p = 0.59$		$t = 2.32$	$p = 0.0206^{+}$	
$\chi^2 = 4.90$	$p = 0.086$		$\chi^2 = 0.22$	$p = 0.90$		$\chi^2 = 5.93$	$p = 0.052$		$\chi^2 = 6.47$	$p = 0.0394$	
										$p = 0.0033$	$d = 0.20$
										$p = 0.0061$	$d = -0.31$
										$p = 0.0001$	$d = -0.63$
										$p = 0.32$	
										$p = 0.012$	$d = -0.42$
										$p = 0.11$	
$\chi^2 = 4.45$	$p = 0.11$		$\chi^2 = 0.69$	$p = 0.71$		$\chi^2 = 3.89$	$p = 0.14$		$\chi^2 = 4.28$	$p = 0.12$	
Interest and experience											
$\chi^2 = 1.02$	$p = 060$		$\chi^2 = 53.60$	$p < 0.0001$		$\chi^2 = 24.64$	$p < 0.0001$		$\chi^2 = 40.87$	$p < 0.0001$	
				$p = 0.28$			$p = 0.11$			$p = 0.22$	
				$p < 0.0001$	$d = -0.60$		$p < 0.0001$	$d = -0.38$		$p < 0.0001$	$d = -0.42$
				$p < 0.0001$	$d = -0.50$		$p < 0.0001$	$d = -0.30$		$p < 0.0001$	$d = -0.50$
$\chi^2 = 2.12$	$p = 0.35$		$\chi^2 = 54.40$	$p < 0.0001$		$\chi^2 = 1.04$	$p = 0.60$		$\chi^2 = 1.54$	$p = 0.46$	
				$p < 0.0001$	$d = -0.60$						
				$p < 0.0001$	$d = -1.21$						
				$p < 0.0001$	$d = -1.39$						
				$p < 0.0001$	$d = -0.68$						
				$p < 0.0001$	$d = -0.88$						
				$p = 0.086$							
$\chi^2 = 1.38$	$p = 0.50$		$\chi^2 = 294.45$	$p < 0.0001$		$\chi^2 = 72.32$	$p < 0.0001$		$\chi^2 = 145.37$	$p < 0.0001$	
				$p = 0.0017$	$d = -0.54$		$p = 0.002$	$d = -0.46$		$p = 0.011$	$d = -0.39$
				$p < 0.0001$	$d = -1.39$		$p < 0.0001$	$d = -0.87$		$p < 0.0001$	$d = -0.96$
				$p < 0.0001$	$d = -2.44$		$p < 0.0001$	$d = -1.45$		$p < 0.0001$	$d = -1.68$
				$p < 0.0001$	$d = -0.90$		$p = 0.0007$	$d = -0.33$		$p < 0.0001$	$d = -0.52$
				$p < 0.0001$	$d = -1.99$		$p = 0.0007$	$d = -0.85$		$p < 0.0001$	$d = -1.23$
				$p < 0.0001$	$d = -1.01$		$p < 0.0001$	$d = -0.54$		$p < 0.0001$	$d = -0.72$
$t = 0.17$	$p = 0.87$		$t = -3.82$	$p = 0.0001$	$d = -0.24$	$t = -3.61$	$p = 0.0003$	$d = -0.22$	$t = -4.68$	$p < 0.0001$	$d = -0.29$
$\chi^2 = 2.76$	$p = 0.25$		$\chi^2 = 33.09$	$p < 0.0001$		$\chi^2 = 14.07$	$p = 0.0009$		$\chi^2 = 12.53$	$p = 0.0019$	
				$p = 0.018^{+}$			$p = 0.49$			$p = 0.79$	
				$p = 0.83$			$p = 0.93$			$p = 0.09$	
				$p = 0.0009$	$d = -0.37$		$p = 0.0045$	$d = -0.35$		$p < 0.0001$	$d = -0.57$
				$p = 0.030^{+}$			$p = 0.59$			$p = 0.095$	
				$p < 0.0001$	$d = -0.51$		$p = 0.0006$	$d = -0.37$		$p < 0.0001$	$d = -0.53$
				$p = 0.0053$	$d = -0.33$		$p = 0.01$	$d = -0.33$		$p = 0.0017$	$d = -0.38$
Reason for taking the course											
$t = 0.31$	$p = 0.76$		$t = -9.21$	$p < 0.0001$	$d = 0.63$	$t = -5.34$	$p < 0.0001$	$d = 0.37$	$t = -5.10$	$p < 0.0001$	$d = 0.35$
$t = 0.98$	$p = 0.33$		$t = 5.33$	$p < 0.0001$	$d = -0.37$	$t = 2.87$	$p = 0.0042$	$d = -0.20$	$t = 3.17$	$p = 0.0016$	$d = -0.22$
$t = 2.13$	$p = 0.033$	$d = 0.17$	$t = -4.40$	$p < 0.0001$	$d = 0.35$	$t = -1.93$	$p = 0.053$		$t = -2.29$	$p = 0.022$	$d = 0.18$
$t = -0.58$	$p = 0.58$		$t = 15.05$	$p < 0.0001$	$d = -1.01$	$t = 6.56$	$p < 0.0001$	$d = -0.44$	$0 = 7.69$	$p < 0.0001$	$d = -0.51$
$t = -2.20$	$p = 0.028$	$d = 0.19$	$t = 11.24$	$p < 0.0001$	$d = -0.96$	$t = 4.35$	$p < 0.0001$	$d = -0.37$	$t = 4.72$	$p < 0.0001$	$d = -0.40$

participants from each class surveyed. When compared with institutional data, five of the seven participating institutions have similar race/ethnicity distributions as in the participating Introductory Geology. At two institutions (UCB and UND), the differences in population distribution between Introductory Geology and the overall population was significant. At UCB, the overall university population of underrepresented ethnicities is 16.4%, yet was only 7.4% of the survey participants ($\chi^2 = 17.43$, df = 2, $p = 0.0002$). At UND, underrepresented ethnicities made up 17.7% of the university population, but only 7.5% of the Introductory Geology students surveyed ($\chi^2 = 21.16$, df = 2, $p < 0.0001$).

Age

Most students surveyed were the traditional age of first- and second-year undergraduates in the U.S. (18–19 years, 62%, $n = 651$) or of third- and fourth-year students (20–21 years, 25%, $n = 262$) (Fig. 1). The remainder was divided into groups of 22–25 years (8%, $n = 83$) and older than 25 years (5%, $n = 52$). More than 80% of the students from each of the four-year institutions (CSUC, MC, NCSU, UCB, and UND) were of traditional undergraduate age (18–21 years), with 50%–86% from each institution being 18–19 years old. In contrast, only 63% of students from Introductory Geology at the 2-year colleges (NHCC and SCC) were of traditional undergraduate age.

Interest and Academic Experience

Major

For the total surveyed population, 21% ($n = 219$) had declared or intended to declare a major in a STEM field, 37% ($n = 405$) were undecided about their field of study, and 41% ($n = 433$) declared or intended to declare a major in a non-STEM field (Fig. 1). This distribution is significantly different from a random distribution, in which 33% of the population would fall in each category ($\chi^2 = 76.88$, df = 2, $p < 0.0001$) (Fig. 1), and significantly different from anecdotal expectations that very few STEM majors enroll in Introductory Geology. While percentages varied from institution to institution, more than 30% of students in every section had yet to declare a major, and less than 30% of students intended to declare or had already declared a STEM major. Within the group of students reporting that had not yet decided on or declared a major, about 80% reported that they were ''not very likely'' or ''definitely not'' planning to major in one of the natural sciences: geology, physics, chemistry, or biology (Fig. 1).

Prior Courses and Interest in Science

A surprisingly large percentage of the students surveyed expressed a high level of interest in science (23%, $n = 238$) (Fig. 1). A total of 51% ($n = 534$) of the students surveyed reported taking more than 3 years of high school science courses, with most students in this study having completed high school biology and chemistry (95 and 86%; $n = 1{,}007$ and 911, respectively), and nearly half (47%, n = 493) completed high school physics, but a surprisingly large 77% (n = 809) reported taking high school Earth science courses. For comparison, the national averages are similar or lower for completion of high school science courses (biology, 93%; chemistry, 66%; physics, 33%; Earth science, 25%) (American Geological Institute, 2009). For 58% ($n = 611$) of the students, this was also not their first college science course. Before taking Introductory Geology, 11% ($n = 113$) had previously taken physics, 16% ($n = 170$), had completed chemistry, 25% ($n = 248$) took biology, and 7% ($n = 72$) enrolled in college courses in more than one science discipline.

Reason for Enrolling

The main reason students report enrolling in Introductory Geology was to fulfill a general education requirement (73%, $n = 765$) (Fig. 1). But students could choose multiple reasons. Some students enrolled to fulfill a major/minor requirement (26%, $n = 278$). Some students had an interest in the topic of geology (31%, $n = 323$), or in the interaction between humans and the environment (18%, $n = 163$), or both (11%, $n = 113$). Others were just looking for an easy course (19%, $n = 196$), presumably with respect to the alternatives of physics or chemistry, and sometimes biology (e.g., Willyard, 2008).

Motivation Scores

In general, overall motivation score varies significantly by age, but neither by gender nor race/ethnicity. Overall motivation is also significantly different when comparing the interest and academic experience groupings and when comparing students who did or did not select any given reason for taking the course (Fig. 2). Although gender did not yield differences in overall motivation, when comparing individual subscales (Tables II and III), extrinsic goal orientation is higher for female students with a small effect size (Student's t-test statistic $[t] = -3.16$, $p = 0.0016$, $d = -0.19$) at the start of Introductory Geology.

The characteristics of two-end member populations (highly motivated and less motivated) can be detected in the overall motivation scores (Fig. 2 and Tables II and III). The highly motivated students include those with an interest in geology and/or the interaction between humans and the environment, and students exhibiting a general proclivity for science (including STEM majors or students very likely to be natural science majors, and students with more than six prior college STEM courses or more than three high school science courses). Overall motivation significantly increased with increasing stated interest in science. Motivation also increased with age (except between 20–21 and 22–25 years), with the oldest students (older than 25 years) being the most highly motivated (Table III).

In contrast, the students least motivated included those expressing low or no interest in science and those not enrolling to fulfill a major or minor requirement (Fig. 2 and Table II). The youngest (18–19 years), those who took three or fewer science courses in high school, those unlikely to be natural science or STEM majors, and those enrolling to fulfill a general education requirement and/or expecting an easy course are also had low overall motivation.

DISCUSSION

Below we discuss motivation, reason for enrolling, and demographic data, without regard for specific details of the course or the instruction. Our focus here is on characterizing the motivations of students at the start of the course in order to provide baseline information on students before instructional methods or other factors of the course influence motivation.

Prior research indicates that students tend to overestimate their scores of motivation and use of learning strategies at the beginning of a course, and these scores decline throughout the semester (Pintrich and Zusho, 2007; van der Veen and Peetsma, 2009). As a result, initial student self-reports of motivation will likely be recalibrated and be represented by a lower score by the end of the semester. It is also important to note that how one student interprets a given value may be different from another, so a score of 3

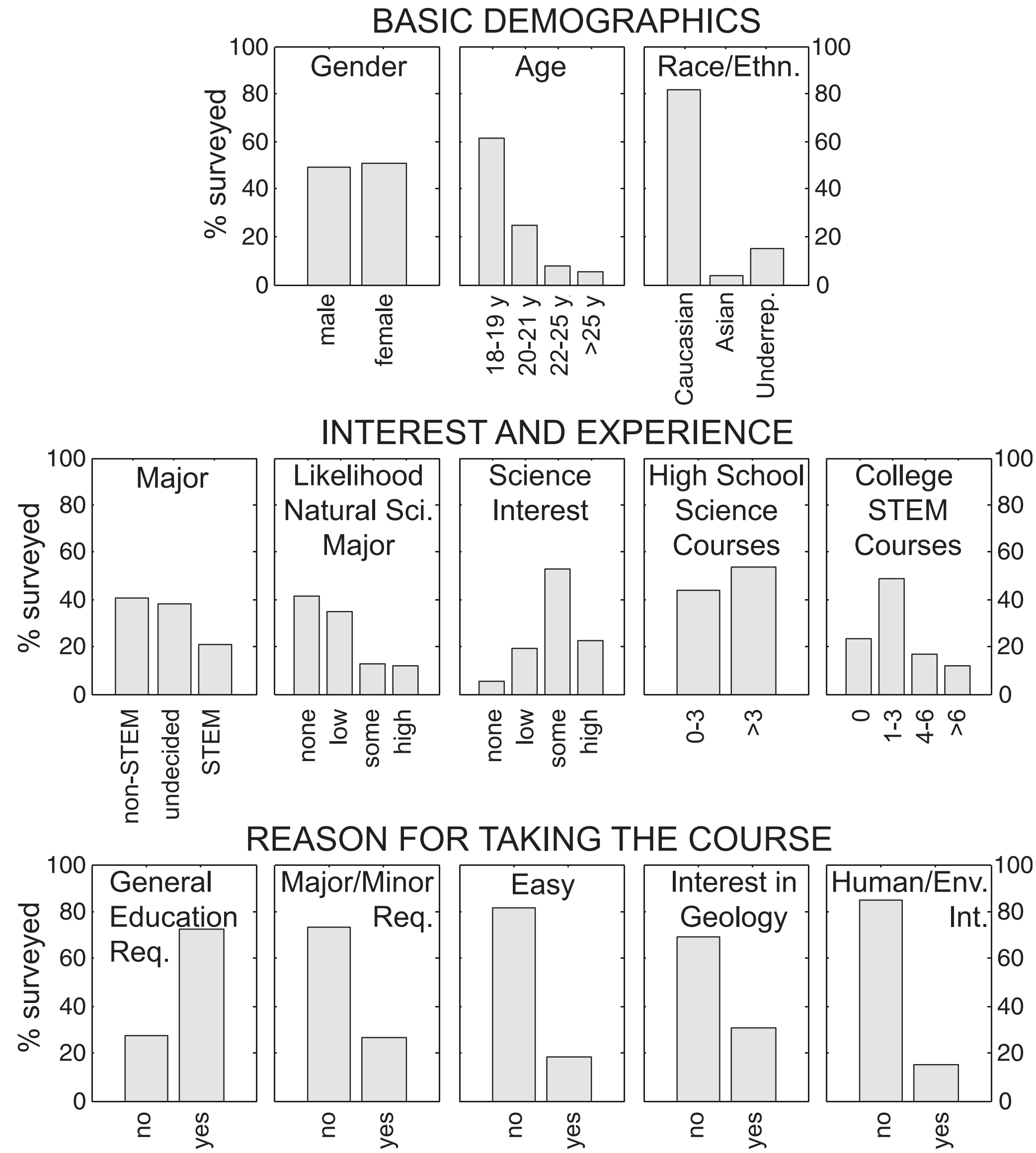

FIGURE 1: Percentages of each group enrolled in Introductory Geology (total $n = 1{,}057$), by basic demographic (top row), interest and experience information (middle row), and reason for taking the course (bottom row). The original survey is shown Supplement A.

out of 7 could mean something different for two different students. However, when there are significant clusters within the survey population, one can begin to draw conclusions about a particular population (Carifio and Perla, 2007). Compared with the rest of the survey population, the "highly motivated" and "less motivated" groups described here are statistically distinct, with significantly different motivation scores.

Highly Motivated Students

It is no real surprise that the more motivated students are the students who have already chosen a STEM major and/or are considering a natural science major, who have taken many prior science courses, and/or who have a high interest in science in general, the interaction between humans and the environment, and/or geology (Fig. 2 and Table III). These students are more likely to value mastery over performance, believe they are in control of their learning, value learning tasks, and have confidence in their learning ability. Many of these attributes have been documented to influence learning in other disciplines (e.g., Vanderstoep et al., 1996; Zusho et al., 2003). These are the most confident students in a class, and it is reasonable to assume that they are the most likely to willingly accept the challenges of a course and seek to develop a deeper understanding of the content. An instructor probably needs to spend less effort motivating them and can focus instead on sustaining their motivation.

Less Motivated Students

Students with less motivation are the students most at risk for poor performance because of their own affect (e.g., Vanderstoep et al., 1996; Zusho et al., 2003; Covington, 2007) and most likely to be a risk for retention (e.g., McKeachie et al., 2002). The less motivated students are the youngest (18–19 years), those with the least proclivity

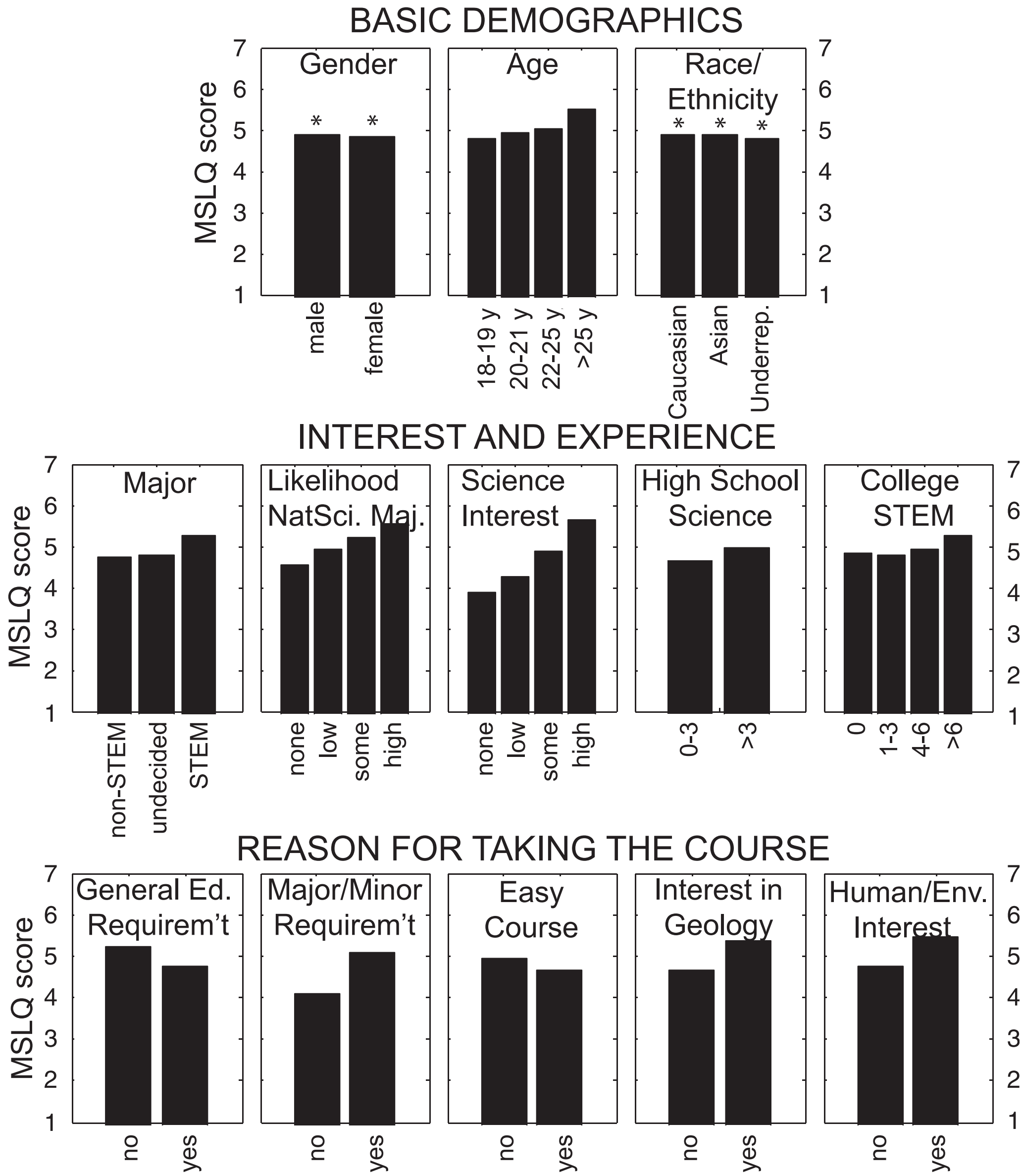

FIGURE 2: Results from the MSLQ, on a 7-point scale, grouped by student demographics, interest, and reason for enrolling in the course. Results compare overall motivation, which is the mean of MSLQ results from intrinsic goal orientation, task value, control of learning beliefs, and self-efficacy. Scores are significantly different at $\alpha = 0.05$ or less (see "Methods"), with $p < 0.0001$ except gender and race/ethnicity (denoted by asterisks). Means and standard deviations for overall motivation and the individual subscales are given in Table II; additional statistics are shown in Table III.

toward science and/or a science major, those expecting an easy course, and/or those taking the course for a general education requirement (Fig. 2 and Table III). It is a disheartening fact that the youngest students and those seeking to fulfill a general requirement are some of the largest demographic groups in the surveyed student population (Fig. 1). A large fraction of the class might thus start the class with lower motivation, particularly lower task value and intrinsic goal orientation (Table II). It is logical to assume many of these students will not do well early in the class, their motivation will deteriorate further, and their learning will be hindered because of a decrease in self-efficacy (Brophy, 2004). This in turn suggests that instructors need to be aware of such a potential downward spiral and deliberately intervene to try and improve student motivation early in the course.

Implications for Improving Student Motivation

Efforts to influence motivation could have the greatest impact when such efforts target those areas with the greatest potential for improvement. Based on our results, we recommend a focus on those motivation factors that already divide Introductory Geology classes into statistically separate populations, namely the categories we used to calculate overall motivation: (1) intrinsic goal orientation, (2) task value, (3) control of learning beliefs, and (4) self-efficacy (Tables I and III). All four of these factors positively correlate with student performance (Pintrich et al., 1991; Zusho et al., 2003).

Previous motivation research has documented multiple strategies that are effective for targeting improvement of self-efficacy and/or control of learning beliefs in specific contexts or in more general terms (e.g., Johnson et al., 1991; Brophy, 2004, McConnell and van der Hoeven Kraft, 2011). We posit that these strategies are likely to be effective in Introductory Geology because these strategies transcend content. For example, self-efficacy can be enhanced by promoting mastery of challenging tasks through small-group activities or by providing students with multiple opportunities to complete assignments (Johnson et al., 1991) or by breaking complex tasks into smaller steps (Rhee Bonney et al., 2005) and providing frequent feedback (Pajares, 2002). Control of learning beliefs can be fostered by seeking student feedback about classroom practices or by providing students with opportunities to make choices about the format of assignments or the components of a grading rubric (Johnson et al., 1991). Margolis and McCabe (2006) suggest a variety of strategies to improve self-efficacy and other motivational aspects of learning including using peers as role models, teaching specific learning strategies, and presenting the students with options and choices.

However, because self-efficacy and control of learning belief scores were relatively high in this study compared with other measures of motivation, more efforts to improve student intrinsic goal orientation and task value might yield larger gains. For example, compared with the rest of the survey population, students enrolling for a general education requirement have significantly lower intrinsic motivation and task value, with medium effect sizes (Cohen's $d = 0.51$ and 0.63, respectively). Thus, for those students, assignment of authentic tasks that incorporate students' personal interests or incorporate current events can help develop heightened intrinsic goal orientation (e.g., Johnson et al., 1991; Hulleman and Harackiewicz, 2009). Similarly, to increase task value in those general education students, instructors can make explicit references to the relevance of course materials and skills to future personal or professional goals outside of science.

Motivations of Students at Universities Versus Colleges

Because most of the students surveyed (85%) were from large research universities, the discussion here is most relevant to similar large-enrollment courses at universities in the U.S. However, although only 15% of the students surveyed were from small liberal arts (SLAC) and community colleges (CC), there are a few comparisons worthy of brief note. First, SLAC students enrolled in Introductory Geology for interest-based reasons at more than double the rates of students at large research universities, and had significantly higher motivation scores than students from other institutions (see Supplement B: Supplemental Data; available at http://dx.doi.org/10.5408/12-287s2). Second, CC students were not significantly different from students at large research universities in terms of motivation or reasons for enrolling in Introductory Geology. An important future study might compare the influence of institution types and other factors such as course size or instructor methods, both on students' reasons for enrolling and on students' changes in motivation from the start to the end of the course.

CONCLUSION

This article is the first to empirically characterize the motivations undergraduate students bring to Introductory Geology, and to link motivation to reasons for enrolling in the course. Results from the demographic surveys and the MSLQ reveal that key aspects of student motivation are influenced by age, potential major, prior coursework in science, reasons for taking the course, and stated interest in science. Although gender and race/ethnicity appear to have little bearing on motivation at the start of Introductory Geology, age is an important distinguishing factor. The data indicate that the more highly motivated students are older students, those with an interest in geology, those who have declared a STEM major or consider a natural science major likely, and those who previously completed several science courses in high school and/or college. These students generally have higher self-efficacy, a greater level of interest or perceived value of the course, and more curiosity and/or desire to learn about geology. Less than 20% of the students enrolled because they perceived geology to be an easy "rocks for jocks" option for fulfilling their science requirement.

Knowing why students enroll in Introductory Geology and their motivational characteristics helps provide information instructors can use to plan successful interventions early in the course. These interventions have the potential to improve skills that will help less motivated students better understand how to learn, and also provide them with the incentive for why they should learn, whereas different interventions can be targeted to help the more motivated students. This study thus has important implications for instructors to better plan courses to meet the needs and values of all students.

Acknowledgments

This work was supported by NSF (DUE-0914404 and DUE-1022917). We appreciate the feedback we received from two anonymous reviewers, the Associate Editor, and the Editor.

REFERENCES

American Geological Institute. 2009. Status of the Geoscience workforce 2009. Available at: http://www.agiweb.org/workforce/reports.html (accessed 6 May 2010).

Artino, A.R. 2009. Think, feel, act: Motivational and emotional influences on military students' online academic success. *Journal of Computing in Higher Education Research and Integration of Instructional Technology,* 21:146–166.

Bandura, A. 2006. Guide for constructing self-efficacy scales. *In* Pajares, F., and Urdan, T., eds., Self-efficacy beliefs of adolescents. Greenwich, CT: Information Age Publishing, p. 307–337.

Biggs, J., Kember, D., and Leung, D.Y.P. 2001. The revised two-factor Study Process Questionnaire: R-SPQ-2. *British Journal of Educational Psychology,* 71:133–149.

Birenbaum, M. 1997. Assessment preferences and their relationship to learning strategies and orientations. *Higher Education,* 33:71–84.

Bodnar, R. 2009. Acceptance of the Society of Economic Geologists silver medal for 2007. *Economic Geology,* 104:1290–1291.

Brophy, J. 2004. Motivating students to learn. Mahwah, NJ: Lawrence Erlbaum Associates, Inc. 418 p.

Burke, R.J., and Mattis, M.C. 2007. Women and minorities in science, technology, engineering and mathematics: Upping the numbers. Northampton, MA: Edward Elgar Publishing. 400 p.

Cano, F. 2006. An in-depth analysis of the Learning and Study Strategies Inventory (LASSI). *Educational and Psychological Measurement,* 66:1023–1038.

Carifio, J., and Perla, R.J. 2007. Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antidotes. *Journal of Social Sciences,* 3:106–116.

Coladarci, T., Cobb, C.D., Minium, E.W., and Clarke, R.B. 2008. Fundamentals of statistical reasoning in education. 2nd ed. Hoboken, NJ: John Wiley and Sons, Inc. 482 p.

Covington, M.V. 2007. A motivational analysis of academic life in college. *In* Perry, R., and Smart, J.C., eds., The scholarship of teaching and learning in higher education: An evidence-based perspective. New York: Springer, p. 661–729.

Dahl, T.I., Bals, M., and Turi, A.L. 2005. Are students' beliefs about knowledge and learning associated with their reported use of learning strategies? *British Journal of Educational Psychology,* 75:275–273.

Duncan, T.G., and McKeachie, W.J. 2005. The making of the motivated strategies for learning questionnaire. *Educational Psychologist,* 40:117–128.

George, Y.S., Neale, D.S., Horne, V.V., and Malcolm, S.M. 2001. In pursuit of a diverse science, technology, engineering and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities. Washington, DC: American Association for the Advancement of Science. Available at: http://ehrweb.aaas.org/mge/Reports/Report1/AGEP/ (accessed 18 January 2012).

Gonzales, L.M., and Keane, C.M. 2010. Who will fill the geoscience workforce supply gap? *Environmental Science Technology,* 44:550–555.

Hackett, G. 1995. Self-efficacy in career choice and development. *In* Bandura, A., ed., Self-efficacy in changing societies. New York: Cambridge University Press, p. 232–258.

Harackiewicz, J.M., Barron, K.E., Tauer, J.M., Carter, S.M., and Elliot, A.J. 2000. Short-term and long-term consequences of achievement goals: Predicting interest and performance over time. *Journal of Educational Psychology,* 92:316–330.

Holbrook, J. 1997. Career potential in the sciences, geology in the high schools, and why anyone would major in geology anyway. *Palaios,* 12:503–504.

Holm, S. 1979. A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics,* 6:65–70.

Hulleman, C.S., and Harackiewicz, J.M. 2009. Promoting interest and performance in high school science classes. *Science,* 326:410–1412.

Husman, J., Derryberry, W.P., Crowson, H.M., and Lomax, R. 2004. Instrumentality, task value, and intrinsic motivation: Making sense of their independent interdependence. *Contemporary Educational Psychology,* 29:63–76.

Johnson, G.R., Eison, J.A., Abbott, R., Meiss, G.T., Moran, K., Morgan, J.A., Pasternack, T.L., Zaremba, E., and McKeachie, W.J. 1991. Teaching tips for users of the Motivated Strategies for Learning Questionnaire (MSLQ), Technical Report 91-B-005. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning. 45 p.

Kraft, K.J., and Husman, J. 2009. Not just jocks studying rocks: The experience of three community college students in an introductory geology classroom. *Geological Society of America Abstracts with Programs,* 41:151.

Kruskal, W.H., and Wallis, W.A. 1952. Use of ranks in one-criterion analysis of variance. *Journal of the American Statistical Association,* 47:583–621.

Krutchkoff, R.G. 1988. One-way fixed effects analysis of variance when error variances may be unequal. *Journal of Statistical Computation and Simulation,* 30:259–271.

Lee, C. 1991. Achieving diversity: Issues in the recruitment and retention of underrepresented racial/ethnic students in higher education: A review of the literature. Alexandria, VA: National Association of College Admission Counselors. 39 p.

Libarkin, J.C. 2001. Development of an assessment of student conception of the nature of science. *Journal of Geoscience Education,* 49:435–442.

Margolis, M., and McCabe, P. 2006. Improving self-efficacy and motivation: What to do, what to say. *Intervention in School and Clinic,* 41:218–227.

Markley, C.T., Miller, H., Kneeshaw, T., and Herbert, B.T. 2009. The relationship between instructor's conceptions of geoscience learning and classroom practice at a research university. *Journal of Geoscience Education,* 57:264–274.

Matuga, J.M. 2009. Self-regulation, goal orientation, and academic achievement of secondary students in online university courses. *Educational Technology and Society,* 12:4–11.

McConnell, D.A., and van der Hoeven Kraft, K. 2011. The affective domain and student learning in the geosciences. *Journal of Geoscience Education,* 59:106–110.

McKeachie, W.J., Lin, Y.-G., and Strayer, J. 2002. Creationist vs. evolutionary beliefs: Effects on learning biology. *The American Biology Teacher,* 64:189–192.

Pajares, F. 2002. Gender and perceived self-efficacy in self-regulated learning. *Theory into Practice,* 41:116–125.

Pekrun, R. 2007. Emotions in students' scholastic development. *In* Perry, R. and Smart, J.C., eds., The scholarship of teaching and learning in higher education: An evidence-based perspective. Dordrecht, The Netherlands: Springer, p. 553–610.

Perrier, F., and Nsengiyumva, J.B. 2003. Active science as a contribution to the trauma recovery process: Preliminary indications with orphans from the 1994 genocide in Rwanda. *International Journal of Science Education*, 25:1111–1128.

Perry, R.P., Hall, N., and Ruthig, J.C. 2007. Perceived (academic) control and scholastic attainment in higher educations. *In* Perry, R., and Smart, J.C., eds., The scholarship of teaching and learning in higher education: An evidence-based perspective, p. 477–552.

Pintrich, P.R. 2003. A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology,* 95:667–686.

Pintrich, P.R., and DeGroot, E.V. 1990. Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology,* 82:33–40.

Pintrich, P.R., Smith, D.A.F., Garcia, T., and McKeachie, W.J. 1991. A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ), Report 91-B-004. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning. 87 p.

Pintrich, P.R., Smith, D.A.F., Garcia, T., and McKeachie, W.J. 1993. Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). *Educational and Psychological Measurement,* 53:801–813.

Pintrich, P.R., and Zusho, A. 2007. Student motivation and self-regulated learning in the college classroom. *In* Perry, R.P., and Smart, J.C., eds., The scholarship of teaching and learning in higher education. An evidence-based perspective. Dordrecht, The Netherlands: Springer, p. 731–810.

Rhee Bonney, C., Kempler, T.M., Zusho, A., Coppola, B.P., and Pintrich, P.R., 2005. Student learning in science classrooms: What role does motivation play?. *In* Alsop, S., ed., Beyond Cartesian dualism. Dordrecht, The Netherlands: Springer, p. 83–97.

Richardson, J.T.E. 2007. Motives, attitudes and approaches to studying in distance education. *Higher Education,* 54:385–416.

Ryan, R.M., and Connell, J.P. 1989. Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology,* 57:749–761.

Ryan, R.M., and Deci, E.L. 2001. To be happy or to be self-fulfilled: A review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology,* 52:141–166.

Schunk, D.H., Pintrich, P.R., and Meece, J. 2008. Motivation in education: Theory, research and applications 3/E. Upper Saddle River, NJ: Pearson Education, Inc. 448 p.

Scott, A.C. 2003. Book reviews. *Geological Magazine,* 4:495.

Thompson, A.M. 1994. Rocks for jocks, with an attitude; small-group learning in a large introductory geology class. *Abstracts of Programs, Geological Society of America,* 26:328.

Underwood, W.D. 2008. Geoscience education in the secondary school. *The Leading Edge,* 27:1330–1332.

Vallerand, R.J. Pelletier, L., Blais, G., and Briere, M.R.N.M. 1992. The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement,* 52:1003–1017.

van der Hoeven Kraft, K.J., Srogi, L., Husman, J., Semken, S., and Fuhrman, M., 2011. Engaging students to learn through the affective domain: A new framework for teaching in the geosciences. *Journal of Geoscience Education,* 59:71–84.

Vanderstoep, S.W., Pintrich, P.R., and Fagerlin, A. 1996. Disciplinary differences in self-regulated learning in college students. *Contemporary Educational Psychology,* 21:345–362.

Van Norden, W. 2002. Problems in geology education: Our high schools are the weakest link. *Palaios,* 17:1–2.

Van Norden, W. and Ingersoll, R.V. 2011. When universities reject high school Earth science. *Abstracts with Program, Geological Society of America,* 43:638.

Wagner, J.R. 2010. Sneaking mathematical concepts through the back door of the introductory geology classroom. *Mathematical Geology,* 3I2:217–229.

Wenner, J.M., Baer, E.M. Manduca, C.A. Macdonald, R.H. Patterson, S., and Savina, M. 2009. The case for infusing quantitative literacy into introductory geoscience courses. *Numeracy,* 2:Article 4. DOI: 10.5038/1936–4660.2.1.4.

Willyard, C. 2008. Rocks: Not just for jocks anymore. *Geotimes,* 53:37–40.

Zusho, A., Pintrich, P.R. and Coppola, B. 2003. Skill and will: The role of motivation and cognition in the learning of college chemistry. *International Journal of Science Education,* 25:1081–1094.