Thinking and Acting Like a Scientist:

Investigating the Outcomes of Introductory Science and Math Courses

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Introduction

Without significant improvement in scientific training in U.S. postsecondary institutions, America stands to lose its competitive edge in scientific achievement, innovation, and economic development. The National Academies' report, *Rising Above the Gathering Storm* (2007), revealed that only 15% of all undergraduates in the U.S. receive their degrees in natural science or engineering, compared with 67% in Singapore, 50% in China, 47% in France, and 38% in South Korea. To continue the United States' level of achievement and innovation in science and engineering, we must not only improve production of undergraduate science majors but also include increasing numbers of diverse people for the future scientific workforce. Indeed, increasing the diversity of scientific talent in science, technology, engineering, and mathematics (STEM) represents a critical part of maintaining and increasing national prominence in science and engineering. As the Council of Graduate Schools (2007) wrote in a report on graduate education and American competitiveness, "it is imperative that the U.S. citizens from all population groups, including those who traditionally have not been highly represented, such as minorities and women, pursue STEM," for only in this way can the United States "maintain its competitive edge" (p. 15).

Central to improving the production of new scientists is the identification of successful students who express and maintain an interest in science. Recent trend data show increases among entering freshmen in terms of interest in science and engineering majors as well as in the number of years of high school coursework completed in biology, math, chemistry and physics (Pryor, Hurtado, DeAngelo, Sharkness, Romero, Korn & Tran, 2008). Recent increases in the enrollment of African American, Latino, and Native American students' in STEM undergraduate and graduate programs also provide encouraging signs that the U.S. has made progress in diversifying the STEM workforce and educational pipeline (National Science Board, 2008). However, the odds of remaining in science until degree completion are still currently very low: Only 24% of underrepresented racial minority (URM) students who begin college as a science major complete a bachelor's degree in science within six years of college entry, as compared to 40% of White students (Center for Institutional Data Exchange and Analysis, 2000).

While there are many individual and institutional factors that account for student attrition (Espinosa, 2009; Seymour & Hewitt, 1997), we wish to sharpen the focus on introductory coursework in science and mathematics. Aspiring students encounter significant obstacles in the form of "gatekeeper" courses almost as soon as they begin their collegiate coursework. These introductory science and mathematics courses are designed to provide foundational learning for all further STEM coursework. Unfortunately, rather than providing tools for future study, such courses tend to discourage students from continuing in the sciences (Seymour & Hewitt, 1997). Drawing from research on science pedagogy and students' habits of mind for scientific work, we explore how student experiences in introductory courses affect students' academic achievement and ability to think and act like a scientist. The purpose of this study is to assess the factors that predict acquisition of these important skills and their relationship with academic achievement (grades) in introductory courses. We hope to understand more about how we can successfully identify and affirm students in introductory science and math courses in college who have the necessary dispositions for science.

Success in introductory coursework represents the necessary first step toward the completion of a bachelor's degree in STEM. Unfortunately, instructors of these courses often grade on a curve (allocating very few A grades) and narrowly assess student performance when assigning the grades. We question whether course grades actually capture the full set of scientific skills that students acquire throughout their introductory coursework. Indeed, instructors typically base grades in introductory science courses on students' ability to acquire and retain specific content knowledge rather than on their development of critical thinking skills, the latter of which are equally necessary for future science careers (Gainen, 1995).

Assessing students based primarily on mastery of content knowledge makes these gatekeeper courses resemble sorting mechanisms that harvest student talent rather than develop it. Several scholars have concluded that prior academic achievement largely determines students' grades in introductory coursework (Gainen, 1995; Kamii, 1990; NCES, 2000; Payzant & Wolf, 1993; Waits & Demana, 1988); therefore, gatekeeper course grades may be more of a reflection of students' prior abilities than the acquisition of knowledge and skills during the course. Particularly in the case of underrepresented racial minority students (as well as women), prior achievement, motivation, and socioeconomic status represent key predictors of future success in college science and engineering courses (NCES, 2000; Payzant & Wolf, 1993; Waits & Demana, 1988). It is important to attempt to untangle these prior preparation and background factors from performance assessment in courses and also to identify whether students develop in introductory courses the higher-order cognitive skills that they need future success in STEM-related careers. Our goal is to provide research that will improve practice in introductory courses that will lead to broader ways of identifying talent in science (academic success), affirm development of student skills in assessing performance, and ultimately increase the pool of students who will continue toward undergraduate degrees in STEM fields.

Literature Review

“Gatekeeper” Courses

Scholars and practitioners generally refer to introductory courses as “gatekeepers” because they represent the first course in a series of classes where knowledge becomes cumulative (Tobias, 1990). Success in introductory courses is, theoretically, a function of both scientific thinking dispositions and content knowledge (Conley, 2005; Hagedorn, Siadat, Fogel, Noral, & Pascarella, 1999). Unfortunately, in practice, college-level introductory science and mathematics courses tend to focus too much on the acquisition of content knowledge and too little on the development of meta-cognitive skills related to critical thinking and scientific literacy (Handelsman, Ebert-May, Belchner, Bruns, Chang, DeHaan, Gentile, Lauffer, Stewart, Tilghman, & Wood, 2004; Hurd, 1997; Williams, Papierno, Makel, & Ceci, 2004). As a result, introductory science courses tend to have relatively high failure and dropout rates (Seymour & Hewitt, 1997). Failure to succeed in gatekeeper courses can lead to difficulty in future courses and may prompt students to switch out of science majors (Labov, 2004; Seymour, 2001).

The high failure and attrition rates observed in gatekeeper courses have been attributed to many sources, including large class sizes, a lack of engaging pedagogy, and high competition among students (Handelsman et al., 2004; Seymour & Hewitt, 1997; Tobias, 1992). Because of the volume of students who enroll in introductory science and math courses, class sizes tend to be large, and instructors tend to rely on lecture to transmit course content. Although lecture may represent an efficient method for presenting domain-specific information to a large audience, it tends to encourage passive learning (Seymour & Hewitt, 1997). In introductory science courses, lectures may fail to engage students in critical thought about the content being presented and may not provide the stimulation necessary to intellectually engage students in learning science and math (Gainen, 1995). Handelsman et al. (2004) note that “active participation in lectures…helps students develop the habits of mind that drive science. However, most introductory courses rely on ‘transmission-of-information’ lectures” that do not encourage active learning (p. 521). Introductory courses that do not engage students can cause students to feel bored and disconnected from science; these feelings in turn may lead intended science majors, high achieving or otherwise, to switch out of the sciences (Seymour & Hewitt, 1997).

In addition to feelings of disengagement in introductory courses, students also often report experiencing high levels of competition among their peers (Gainen, 1995; Mazur, 1992; Seymour & Hewitt, 1997; Tobias, 1992). Much of the competitive culture within introductory science and math courses originates from the grading practices of faculty teaching these courses, as they tend to grade students on a curve (Seymour & Hewitt, 1997). Grading on a curve discourages collaboration and cooperation among students because helping one’s peers in class could disadvantage an individual student in terms of final (e.g., post-curve) test scores (Mazur, 1992). Indeed, this grading technique engenders a “survival of the fittest” mentality among students in introductory courses (Epstein, 2006). Such competitive mentalities seem to be strongest among science students. Vahala and Winston (1994), for example, found that students taking laboratory science classes reported experiencing a more hostile classroom environment than did their peers in English courses.

Classroom Environments and Instructor Pedagogies

A competitive culture represents one of several climates that students may encounter in their introductory courses. Classroom environments can have a significant effect—positive or negative—on student achievement (Fraser & Fisher, 1982; Prenzel, Kramer, & Dreschel, 2002; Seidel, 2006). Scholars consistently have concluded that competitive classroom climates have negative effects on students' learning and performance. For example, Walberg (1979) examined the effect of classroom climate on student achievement and retention and found that students who experienced more competitive classroom contexts tended to have higher rates of failure and lower levels of self-confidence than their peers in more cooperative environments. Using data collected from 1,083 science students across 116 classrooms, Fraser and Fisher (1982) found positive correlations between students' adoption of scientific attitudes and their perception that the course encouraged participation. In general, it seems that science students who perceive that courses have a sense of cohesion and goal orientation tend to have higher levels of academic achievement compared to their peers who had negative perceptions of their classroom context (Haertel, Walberg, & Haertel, 1981). These studies imply that if gatekeeper courses have competitive learning climates that reduce collaboration by forcing students to contend with one another for grades, most or all students may be negatively affected.

Because of the potential implications associated with how students perceive their learning environment, both in terms of engagement in learning and the learning climate, many scholars have examined how pedagogical strategies can be adjusted to encourage student engagement and collaboration in class. For example, to examine how the extent of lecture and group work affected student learning, Knight and Wood (2005) conducted an experiment with two offerings of an upper-division biology course. In the first term, the course instructor used traditional lecture methods to teach the course. In the second term, the instructor employed not only lecture but also a number of cooperative and problem-solving activities. Knight and Wood (2005) compared students' scores on pre-and post-tests from the beginning and end of each term, respectively, and found that students who had exposure to the cooperative classroom environment experienced greater knowledge gains compared to their peers in the more traditional, lecture-heavy classroom environment. The authors repeated this experiment in a subsequent term and obtained similar results.

A related study by Armstrong, Chang, and Brickman (2007) examined how students exposed to cooperative learning environments compared to their peers taking courses with a traditional lecture format. The experiment included two instructors, each of whom taught two sections of biology: one section utilized a traditional lecture format while the other section included more cooperative learning and group activities. Controlling for pre-test scores, students in the cooperative learning groups showed significantly more improvement in understanding than did their peers in the lecture condition. The cooperative group also had higher attendance rates and expressed more enjoyment and connection with the work.

A large number of studies over the last 25 years have concluded that incorporating small-group and collaborative learning activities in large STEM courses provides students with a number of benefits. Indeed, a meta-analysis by Springer, Stanne, and Donovan (1999) demonstrated that students who enrolled in STEM classes with a greater emphasis on small-group and collaborative learning had higher levels of academic achievement, higher rates of persistence in STEM courses, and more positive attitudes about academics in general than did their peers who had taken courses dominated by lecture. The specific type of collaborative learning does not seem to matter; students have benefited from a wide range of interactive and active learning activities, including interactive-engagement strategies (Hake, 1998); student-faculty interactions (Astin, 1993; Smith, Sheppard, Johnson, & Johnson, 2005); course discussion (Allen & Tanner, 2002, 2005; Tanner & Allen, 2005), student feedback or clicker systems (Wood, 2004), and problem-based learning exercises (Shipman & Duch, 2001).

Pedagogical strategies that encourage engagement in discussion and group activities not only promote achievement and persistence but they also provide students with opportunities to think critically about scientific concepts and their applications and thus promote higher-order thinking skills (Allen, Duch, & Groh, 1996; Freedman, 1994; Sagan, 1996). As Smith, Sheppard, Johnson, and Johnson (2005) describe, collaborative learning exercises offer an opportunity for the sharing of multiple perspectives on a problem, which allows students to evaluate several sources of evidence and rationales before deciding on a path toward resolution. Encouraging student participation in class discussions has been linked to higher-order critical thinking skills by many researchers (cf. Tsui, 2002), as has using students' ideas in class, providing opportunities for student interactions in class, and encouraging more classroom involvement in general (Smith, 1977, 1981; Terenzini, Theophilides, & Lorang, 1984). Further, scholars have linked growth in critical thinking skills to other activities that encourage active and open-ended learning, including participation in research projects (Astin, 1993; Tsui, 1999), academic enrichment programs (Summers & Hrabowski, 2006), and taking essay exams (Astin, 1993).

Supportive Learning Environments and the Skills Needed for Scientific Success

As noted by Walberg (1979), Fraser and Fischer (1982), Vahala and Winston (1994), and others, students' perceptions of the classroom environment can have a direct effect on their academic achievement and cognitive development. Hostile or competitive environments tend to have negative effects on students' achievement whereas positive, supportive, and collaborative classroom contexts enhance student learning. Prenzel, Kramer, and Dreschel (2002) identified six necessary conditions for a supportive learning environment: relevance of content; quality of instruction; teacher's interest; social relatedness; support of competence; and support of autonomy. Environments that provide relevant content offer students the opportunity to see the real-world application of concepts and content knowledge. Quality instructors transmit information to students in clear, coherent ways that meet the learning needs of the particular audience in the classroom. Interested instructors demonstrate their commitment to student learning and an ethic of care in regard to students' academic problems. Classrooms that contain elements of social relatedness emphasize attributes of collegiality and cooperation. Instructors that offer students support of competence provide individualized, constructive feedback on coursework. Finally, learning environments containing support of autonomy offer students opportunities for exploration in problem solving, which allows for multiple approaches for reaching resolutions and conclusions.

Seidel (2006) writes that classrooms with these six elements engender greater self-motivation among students while allowing them to become more self-directed in their learning. Students who feel supported by their professors and have opportunities to engage in constructive ways with their peers likely increase the frequency with which they take risks in the classroom and offer alternative approaches to solving problems (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994). Additionally, participating in an environment that encourages the application of abstract scientific concepts to real-world experiments and problems provides students with the opportunity to understand the relevance and importance of the material presented in class. Exercises that allow for such application enable students to transition from abstract knowledge to more concrete understanding.

Specifically connected to the transition from the abstract to the concrete is students' ability to learn to think and act like scientists. The ability to think like a scientist involves asking questions, identifying problems, evaluating evidence to make appropriate judgments, and finding ways to make scientific findings relevant and accessible to society at large (Williams, Papierno, Makel, & Ceci, 2004). Koslowski (1996) describes two approaches related to how students learn to act and think like scientists: domain-specific and domain-general. Instructors who take a domain-specific approach to teaching science rely heavily on transmitting specific scientific concepts to students, having students memorize textbook definitions, and teaching algorithmic methods for problem solving. The domain-specific approach assumes that students will develop higher-order, critical thinking skills as they apply the scientific concepts and knowledge taught in the classroom (Barnett & Ceci, 2002).

In contrast to the domain-specific approach to teaching science, instructors who utilize domain-general pedagogical techniques tend to focus more on the development of reasoning and critical thinking skills that can be applied to a variety of disciplines (Koslowski, 1996; Resnick, 1987). The development of these higher-order thinking abilities provide students with the requisite skills to more accurately evaluate evidence and choose multiple paths in problem solving (Kuhn, Garcia-Mila, Zohar, & Anderson, 1995). Rather than merely memorizing a set of causal relationships, students who have developed appropriate levels of critical thinking skills can infer causal relationships from evidence presented, and this ability to reason and think critically about evidence represents a key difference between the domain-specific and domain-general approaches to teaching.

Additional influences on student success in introductory STEM courses

Course content, pedagogical practices, and learning environments all significantly affect students' achievement and development of scientific and general critical thinking skills in college classrooms. However, scholars have identified a number of experiences external to the classroom environment that also significantly contribute to growth in students' critical thinking abilities. For example, a substantial body of research has examined the benefits of research participation for undergraduate students, showing that engagement in research projects can help students tremendously in terms of their ability to develop scientific literacy and critical thinking skills because these opportunities provide students with hands-on learning experiences in which they must apply concepts learned in the classroom to real-world scenarios (Barlow & Villarejo, 2004; Foertsch, Alexander, & Penberthy, 1997; Lopatto, 2004; Sabitini, 1997). Sabitini (1997) tracked the progress of several undergraduate students who conducted research with him, and found that these students reported substantial gains in their problem-solving abilities. The students also appreciated the opportunity to engage in a team setting.

Another activity that has been connected to growth in achievement and critical thinking skills is participation in peer tutoring (Bulte, Betts, Garner, & Durning, 2007; Glynn, MacFarlane, Kelly, Cantillon, & Murphy, 2006; Lockspeiser, O'Sullivan, Teherani, & Muller , 2008). Glynn et al. (2006) conducted a qualitative study in which fifth-year medical students served as peer tutors for groups of second-year medical students for a specific educational module related to the Early Patient Contact program. The second-year students reported that the peer tutors found ways to make the information contained in the module relevant to them, which encouraged a deeper understanding as well increased knowledge retention. Glynn et al. (2006) concluded that peer tutoring environments provide students with a safe learning environment, which encourages students to ask questions and discuss content more freely than they would in the context of a classroom. In a similar study, Lockspeiser et al. (2008) found that medical students who took advantage of peer-tutoring programs reported that they gained more support from their tutors than from the classroom context, and this helped to put them at ease about their ability to learn all of the information required of first- and second-year medical school students.

Overall, it seems that receiving tutoring or serving as a tutor can help students make learning connections they might otherwise not have made, especially if their only other source of course content has been from textbooks and lecture.

Conceptual Framework

Building on previous research, the hypothesized model for this study takes a broad view of success that encompasses not only the narrow construct of students' course grade but also students' ability to think and act like scientists. As Figure 1 shows, we hypothesize that student success will be affected by a variety of factors that can broadly be broken down into several conceptual areas: students' experience of the learning environment in their introductory courses; course pedagogy; students' out-of-class experiences with research and tutoring; the amount of effort students expend on the course; and students' critical thinking dispositions. The model in Figure 1 proposes that these factors significantly affect student success after taking into account students' demographic characteristics, pre-tests of success, predispositions toward scientific thinking, and pre-college experiences.

As shown in Figure 1, the experience of the course learning environment is multifaceted, encompassing how students feel about and interpret their instructors' teaching methods, coursework, and learning environment. Course pedagogy is conceived of as the kind of instructional methods that are used, the emphasis of the coursework, and how often feedback about course progress/performance is given. Student effort, background characteristics, and initial propensity toward thinking and acting like a scientist are included in the model because these factors have all been shown to affect student success in coursework; controlling for these variables allows for the examination of the unique impact of the introductory science course and other related experiences on student success.

Critical thinking dispositions, measured using the California Critical Thinking Dispositions Inventory (CCTDI), are also included as predictors of student success. Developed by Facione, Sanchez, and Facione (1993), the CCTDI measures individuals' critical thinking skills across seven dimensions: inquisitiveness, open-mindedness, systematicity, analyticity, truth-seeking, critical thinking self-confidence, and maturity. The CCTDI measures have been shown to be significantly associated with college student GPAs (Giancarlo & Facione, 2001), and were developed in part as markers for cognitive skills typically used in the sciences, such as interpretation, analysis, inference, evaluation, and explanation (Facione, Sanchez & Facione, 1993). Including the CCTDI measures in our model allows us to use a standard measure of dispositions for critical thinking to assess a relationship with estimations of student gains in scientific thinking during introductory courses.

In terms of the outcomes in the model, student "success" was assessed using three independent measures: thinking like a scientist, acting like a scientist, and students' course grade. Our intention was to separate students' thinking preferences and performance as a scientist from the evaluation students received in the course. As shown in Figure 1, we hypothesized that post-test scores of thinking and acting like scientists would be significantly predictive of students' final course grade. We hypothesized the presence of these causal paths for two reasons. First, students reported their self-ratings on items related to thinking and acting like scientists prior to the posting of their course grade; thus, the temporal order in which we collected these measures dictated that students' end-of-term dispositions toward science may affect their final course grade. Second, we wanted to assess whether course grades were associated with the skills necessary to be a successful scientist or whether grades are independent of these skills.

Method

Data and Sample

We collected the data for this study in conjunction with a larger national research project that examines the facilitators of and barriers to URM science students' progression toward research careers in the sciences. Funded by the National Institutes of Health and the National Science Foundation, the national project examines both individual experiences and institutional contexts that affect students' development as science majors during and beyond college. For the present study, we collected data using two student surveys administered in introductory science and math courses at five colleges and universities across the country. The five campuses included one historically Black university, two predominantly White institutions (PWI), and two Hispanic-Serving institutions (HSI). These five institutions were selected because of their reputations for graduating significant numbers of students in the biomedical and behavioral sciences, and three of the five had NIH-funded undergraduate research programs. At each institution, we administered the survey to at least two introductory science or math courses. Each institution had at least one section of biology and chemistry sampled; some had more than one section of biology represented, and one included a calculus section. Each of the sampled courses was a "gatekeeper," as each represented the first in a series of classes where knowledge is cumulative. In other words, success in any one of the courses in this study was necessary to move onto the next course in the sequence.

Students in each introductory course were surveyed at the beginning and end of the spring 2007 academic term. The "Science Student Experience Pre-Survey" was given at the beginning of the term, and collected information on students' self-rated academic and science abilities, their level of comfort in articulating and applying science concepts in experiments, and demographic information. Many of the items on the pre-survey were based on Conley's (2005) work in identifying critical skills and dispositions students should have for success in introductory science courses. Administration of the pre-survey yielded 583 responses across the five campuses and 12 classrooms, which corresponded to a 25% response rate.

The "Science Student Experience Post-Survey" was given at the end of the term before students received their final course grade. This survey followed up with students on many of the same self-rated abilities covered in the pre-survey and had a particular focus on students' skills for and dispositions toward thinking and acting like scientists. The post-survey also included 75 items from the CCTDI (Facione, Sanchez, & Facione, 1993), items covering specific pedagogical techniques used in the introductory courses, and student experiences within and outside of the course.

The pre- and post-surveys were administered online during the first three weeks of the term and during the final three weeks of the term, respectively. To assist with survey administration, instructors reminded students about the survey at the end of many of the classes during the administration period. Additionally, we sent students emails during these timeframes to provide survey reminders. As an incentive, students were given the chance to win one of 20 $50 gift certificates. The surveys yielded 263 longitudinal cases that form the analytic sample for this study. The longitudinal response rate was 52%.

Because the analyses used listwise deletion of cases with missing data on the dichotomous variables in the model, the final analytic sample was reduced to 255 cases. To adjust for non-response bias between the two surveys, we created response rates based on students' gender, race, and academic class (e.g., freshman, sophomore, etc.). We compared the weighted longitudinal sample (N=255) with the unweighted pre-survey dataset (N=583) and determined that the response weights did not significantly alter the means and distributions of key variables from the pre-survey. Satisfied that the weighted post-survey sample represented the pre-survey response population, we proceeded with the use of the response weights in the structural equation model.

The majority of respondents in the final sample were female (70%) and most were either White (32%) or Asian (43%). Native Americans made up 2% of the sample, African Americans 8%, and Latinos/Chicanos 13%. Just over three-quarters (76%) indicated that English was their native language. The vast majority of students in the sample (86%) reported that they were majoring in a STEM field; most of the others (73% of those who had "other" majors or who were "undecided") believed it was likely that they would major in science. Sixty-four percent of students were in their first year of attendance at their institution, 27% were in their second year of attendance, and the remainder were in their third year of attendance or had been attending longer than three years. Appendix B provides the means and standard deviations of all of the variables in the final model.

Measures

This study primarily focuses on three outcome variables, measured at or near the end of the academic term. Two outcomes are latent constructs that represent students' self-rated ability to think and act like scientists, and these same constructs were measured as pre-tests in order to control for prior abilities and experiences. The third outcome measure is a variable representing students' final grade in their introductory course, which we collected from registrar's offices at each institution. The two latent constructs, ability to think like a scientist and to act like a scientist, were composed of a set of indicator variables identified through factor analysis. A confirmatory factor analytic model was run in EQS 6.1 to confirm that the relationships between the indicator variables and the constructs held up for both the pre-test and the post-test. Table 1 presents the indicator variables explained by the latent constructs, their factor loadings, and the fit indices for the measurement model.

As shown in Figure 1, the hypothesized model includes variables representing students' background characteristics, prior academic achievement, exposure to pedagogical techniques, experiences within the course, college experiences external to the course, and CCTDI sub-scales. Appendix A lists all of the measured variables and coding schemes.

Analyses

Structural equation modeling (SEM) in EQS 6.1 allows researchers to simultaneously estimate the relationships among sets of variables and confirm latent constructs (Bentler, 2006; Bentler & Wu, 2002). Parameter estimates are generated by analyses of estimated covariance matrices. SEM accounts for measurement error and provides overall goodness of fit indices to determine the adequacy of the model, both of which represent advantages over traditional path analysis (Laird, Engberg, & Hurtado, 2005). To assess model fit, we relied on three fit indices: non-normed fit index (NNFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA). NNFI and CFI values above 0.90 indicate adequate model fit, while RMSEA scores below 0.06 indicate an appropriate level of fit (Raykov, Tomer, & Nesselroade, 1991).

Our approach began with a confirmatory factor analysis that tested the adequacy of our measurement model. The measurement model included the observed variables and their associated latent constructs for both the pre- and post-surveys. This measurement model confirmed the factor structure of the two pre-test factors and their associated post-tests.

In the second step, we added all of the hypothesized predictors and paths presented in Figure 1 to test the full structural model. We relied on prior research and theory when considering the Wald and LaGrange Multiplier tests, which suggested the deletion or addition of causal paths in the model to improve model fit. As the final model, presented in Figure 2, illustrates, we removed several paths from measures of course pedagogies to the three outcome variables. Similarly, we deleted several of the paths that connected measures of the course environment with the three outcome variables. Finally, we removed several of the CCTDI measures and their hypothesized relationships with the three outcomes. If all paths from a variable were removed, we dropped the variable from the analysis..

Limitations

A number of constraints with the methodology and the data may limit the generalizability of our findings and conclusions. First, we situated our study within 12 classrooms across five campuses of varying type, size, selectivity, and mission, and this constraint may limit the generalizability of our findings to other types of institutions and classroom contexts. Second, the sample size utilized in this study was admittedly small, which limited the number of variables we could include in the analyses. Third, these data have a nested design in which students are clustered within classrooms which are clustered within institutions. Because of sample size considerations within each classroom and within each institution, we did not disaggregate data by classrooms or by institutions. Additionally, the number of classrooms and institutions prevented us from exploring multi-level models in SEM. Finally, because this study examined students' experiences in a single introductory course, the short timeframe in which we administered the surveys may have affected the amount of change detected in students' learning to think and act like scientists. This study chose to focus on student changes in these items over the span of a single academic quarter; had students been tracked over a longer period of time, we may have detected more substantial changes in these outcomes.

Results

Table 1 presents the results of the measurement model for the four latent variables in the study: pre- and post-tests of thinking like a scientist and acting like a scientist. The model statistics suggest that the model fits the data well. The Satorra-Bentler chi-square statistic is 300.69 ($df = 305$, $N = 255$, $p = 0.55$), and the fit indices are NNFI =0.98, CFI = 0.98, and RMSEA = 0.03. Table 1 shows the factor loadings of observed variables on each of the four factors; all variables loaded highly on the relevant factor. Given the good fit of the measurement model, we proceeded with the estimation of the structural model.

Table 2 shows the unstandardized regression coefficients, the standardized regression coefficients, the standard errors, and the significance levels for the direct effects in the final model. Figure 2 presents causal paths for the final structural model. Solid lines indicate significant effects in the final model whereas dotted lines represent non-significant paths. The Satorra-Bentler chi-square statistic for the final model was 1,285.69 ($df = 1{,}047$, N = 255, $p < 0.001$), and the fit indices were: NNFI = 0.91, CFI = 0.92, and RMSEA = 0.03. Although the chi-square statistic was significant, it is highly dependent on sample size and degrees of freedom (Bentler, 2006). The other indices suggest that the model appropriately represents the relationships among students’ characteristics at the beginning of the course, their experiences and exposure to pedagogical strategies within the course, and the three primary outcomes.

Considering the results of the predictors related to students’ high school math and science GPA, only tutoring another student in high school appeared to have a significant relationship with this endogenous variable ($\beta = 0.23$, $p < 0.01$). We detected no significant differences between men and women in their math and science high school GPA. Additionally, we did not find differences in math and science high school GPA between URM students and their White and Asian American counterparts. Just 6% of the variance in high school math and science GPA was explained with these predictors.

Examining the results related to the two endogenous pre-tests in the model of thinking and acting like scientists, the coefficients in Table 2 indicate that students' scores on the AP Chemistry test significantly and positively predicted the pre-tests of acting like a scientist ($\beta = 0.18$, $p < 0.05$) and thinking like a scientist ($\beta = 0.20$, $p < 0.05$). Women appeared to rate themselves lower than their male classmates on the both acting ($\beta = -0.29$, $p < 0.01$) and thinking ($\beta = -0.36$, $p < 0.01$) like scientists. The frequency with which students spent time tutoring their peers in high school appeared to be significantly and positively related to students' self-rated ability to think like a scientist ($\beta = 0.12$, $p < 0.05$). These predictors accounted for 12% and 18% of the variance in the pre-tests of acting and thinking like a scientist, respectively.

The most important predictor in students' self-rated ability to think like a scientist at the end of the academic term was their self-rated pre-test ($\beta = 0.57$, $p < 0.001$). Three CCTDI measures significantly predicted students' post-test scores for thinking like a scientist. Openmindedness had a significant and negative relationship with the outcome ($\beta = -0.19$, $p < 0.01$) while analyticity ($\beta = 0.14$, $p < 0.05$) and critical thinking self-confidence significantly and positively predicted post-test scores on thinking like a scientist.

Only one course pedagogical strategy significantly predicted thinking like a scientist at the end of the academic term. Students who agreed with the statement that the instructor primarily used lecture to present course material scored themselves higher on their abilities to think like scientists compared to their peers in less-lecture-intensive environments ($\beta = 0.13$, $p <$

0.05). We should note that 96% of students either agreed somewhat or agreed strongly that their instructor primarily used lecture methods for course instruction. Further inspection of student responses to the lecture variable by institution and course shows that a very small proportion of students in each class disagreed that the course was primarily lecture. Additional post-hoc analyses indicate that virtually all students who disagreed that the course was primarily lecture also indicated that they "never" attended class or lab. Therefore, the lecture variable is likely functioning as a proxy for class and lab attendance, and the positive predictive power of lecture on thinking like a scientist does not mean that lecture actually promotes this particular disposition but rather that attending lecture (class) encourages students to think more like scientists.

Feeling overwhelmed negatively contributed to respondents' ability to think like scientists ($\beta = -0.14$, $p < 0.01$); however, intending to major in one of the biomedical or behavioral sciences had a positive association with thinking like a scientist at the end of the academic term ($\beta = 0.15$, $p < 0.05$). The model accounted for approximately 61% of the variance in students' ability to think like scientists.

A number of the same variables emerged as significant predictors of students' ability to act like scientists at the end of the academic term. Similar to thinking like a scientist, students' pre-test represented the most important predictor of their self-rated ability to act like scientists at the end of the academic term ($\beta = 0.56$, $p < 0.001$). Openmindedness was negatively associated with acting like a scientist ($\beta = -0.15$, $p < 0.05$) whereas critical thinking self-confidence positively predicted this disposition ($\beta = 0.40$, $p < 0.01$). Students in courses that relied heavily on lecture as a pedagogical technique tended to rate themselves higher on their ability to act like scientists ($\beta = 0.16$, $p < 0.05$). Again, lecture appears to serve as a proxy for course attendance.

Additionally, students who felt overwhelmed by course expectations reported lower scores on the construct acting like a scientist ($\beta = -0.26$, $p < 0.01$). These direct effects accounted for approximately 60% of the variance in students' self-rated ability to act like scientists.

The final outcome variable of interest was students' course grades. We were especially interested in examining the relationship between students' scores on thinking and acting like scientists and their final course grade. As shown in Table 2, we did not detect a significant relationship between these dispositions and students' grade. Instead, we found a significant and positive effect from students' prior academic achievement ($\beta = 0.19$, $p < 0.05$) and prior participation in a high school science research program ($\beta = 0.13$, $p < 0.05$). Additionally, students in classroom environments that encouraged working in small groups earned higher grades than their peers in learning environments that did not emphasize group work ($\beta = 0.21$, $p < 0.05$). Cramming for exams ($\beta = 0.19$, $p < 0.01$) and seeking tutoring on campus ($\beta = 0.10$, $p < 0.05$) significantly and positively predicted students' final course grade. Similar to the findings related to thinking and acting like scientists, feeling overwhelmed negatively affected students' academic performance in the introductory course ($\beta = -0.23$, $p < 0.01$). In fact, feeling overwhelmed represented the strongest predictor of students' final grade in the course – even stronger than their average math and science GPA in high school. We did not detect any significant effects on course grade from students' feelings of competition, time spent in lab, participation in a college research program, or academic major. Similarly, we did not identify any significant paths from the CCTDI measures to students' final course grades, as indicated by the dotted lines in Figure 2. The predictors for students' final course grade accounted for approximately 22% of the variance in this measure.

Table 3 presents the indirect effects for the three outcome measures. Students' AP chemistry test scores, operating through each of the respective pre-tests had significant, positive indirect effects on both thinking ($\beta = 0.11$, $p < 0.05$) and acting ($\beta = 0.10$, $p < 0.05$) like scientists. In the same way, being female had a significant, negative indirect effect on thinking ($\beta = -0.21$, $p < 0.05$) and acting ($\beta = -0.16$, $p < 0.05$) like scientists. Finally, tutoring another student in high school also had a significant, positive indirect effect on thinking like a scientist ($\beta = 0.07$, $p < 0.05$). Each of these indirect effects operated through the respective pre-tests of these factors.

Table 3 shows one significant indirect effect for students' final course grades. Tutoring another student in high school appeared to exert a significant, positive indirect effect on students' final course grade through high school science GPA ($\beta = 0.06$, $p < 0.05$). The other indirect effects on students' final course grade were not significant.

Discussion and Conclusion

One of the primary goals of higher education is to educate cadres of graduates whose talents can improve society and global economic competitiveness. Young scientists represent a key part of this future generation, and, as technology increasingly becomes part of everyday life, new scientific talent becomes increasingly important (Council of Graduate Schools, 2007). The National Science Foundation's National Science Board notes that science and engineering serve as the primary drivers of both economic growth and national security, and that "excellence in discovery and innovation in science and engineering…derive from an ample and well-educated workforce" (National Science Board, 2003, p. 7). Improvement in science teaching and classroom practice is now more critical than ever to maintaining America's competitive edge with a more diverse student population that has the potential to become the next generation of scientists.

Although students' grades in introductory courses may be useful in sorting students, they do not seem to be useful in capturing gains in dispositions for scientific work or dispositions for critical thinking. Our model demonstrated that grades were not significantly related to students' ability to think like a scientist and act like a scientist, nor were they related to any CCTDI sub-scales. Instead, students' course grades were related to cramming for exams, tutoring, and feeling overwhelmed by course expectations. This confirms previous work that found college-level introductory science and mathematics courses tend to focus too much on the acquisition of content knowledge and too little on the development of meta-cognitive skills related to critical thinking and scientific literacy (Handelsman, et. al., 2004; Hurd, 1997; Williams, Papierno, Makel, & Ceci, 2004). As we expected, students' course grades were in large part predicted by high school preparation (grades and research experience).

If grading practices are the primary sorting mechanism colleges employ in science, and if grades in large introductory are meted out on a curve with relatively few students earning high marks, this means that talented students who do not out-compete their peers may be weeded out of science majors very early on in their college career. Students who do not earn top grades do not necessarily lack the skills needed to be a good scientist; they may simply lack the prior preparation or study skills needed to perform well in lecture-based classes that reward cramming for exams. To keep talented students in science majors, we need to broaden performance criteria and assessment techniques. Grades alone will not identify the nascent scientific talent that exists among college students.

Interestingly, students earned higher grades when they were involved in courses where group work was encouraged. This is congruent with the literature that shows the myriad benefits of group work in terms of student performance (Armstrong, Chang, & Brickman, 2007; Knight

& Wood, 2005; Shipman & Duch, 2001; Springer, Stanne, & Donovan, 1999). Providing students with opportunities to share ideas and evaluate multiple sources of evidence reinforces content and concepts presented in class (Armstrong, Chang, and Brickman, 2007; Knight & Wood, 2005). This reinforcement of learning may have longer-term benefits in terms of students' retention of domain-specific knowledge (Koslowski, 1996; Kuhn, Garcia-Mila, Zohar, & Anderson, 1995).

Students also appear to experience benefits in their learning from tutoring programs on campus. Students who sought tutoring on campus for help in their coursework also earned higher grades. Similarly, having tutored another student in high school provided students with an indirect benefit on their final course grades. Respondents who tutored their peers in high school tended to earn higher grades in their high school math and science courses, which then translated into a higher grade in their introductory science or math course in college. These findings suggest that it is possible to harness the power of peer learning, model team work, and also to reward this cooperation in classrooms.

One troubling aspect of the classroom environment that emerged from this study relates to students' feelings of being overwhelmed by course expectations. Respondents who indicated that they agreed with the statement that they felt overwhelmed by course expectations tended to earn lower course grades and score lower on the constructs of thinking and acting like scientists. These feelings may represent a proxy for students' perception regarding their prior preparation for introductory science and math coursework or a general naïveté about what is expected from students enrolled in introductory courses. Indeed, Seymour and Hewitt (1997) concluded that students' feelings of being overwhelmed with coursework often resulted from poor preparation in high school and unrealistic expectations for the work associated with being a science major, which eventually led students to leave the sciences.

Although students who felt overwhelmed earned lower course grades and scored lower on the scientific habits of mind, the findings suggest that three of the critical thinking subscales had significant associations with thinking and acting like scientists. Interestingly, we found a negative relationship between openmindedness and students' dispositions toward science. The CCTDI openmindedness subscale measures the extent to which individuals show tolerance of others' opinions and perspectives. Given this definition, the negative effect of this variable on students' self-rated abilities to think and act like scientists is not surprising, as individuals who have more of a relativistic perspective may be less likely to embrace the objective, empirical nature of science.

In contrast to openmindedness, students' critical thinking self-confidence had a significant, positive relationship with both thinking and acting like a scientist. This finding corresponds to the higher-order thinking In contrast, the habits of mind for scientific work were supports earlier studies on the development of higher-order thinking skills (Koslowski, 1996). These findings indicate that students who rate themselves higher on their meta-cognitive abilities also tend to be more likely to develop domain-general scientific skills that enable them to infer causal relationships and more adeptly evaluate evidence when engaging in problem-solving activities (Kuhn, Garcia-Mila, Zohar, & Anderson, 1995).

Analyticity was the third critical thinking subscale that related to thinking like a scientist. Analyticity measures the extent to which students can anticipate the multiple outcomes and consequences in decision-making processes. Students with high scores on the analyticity subscale appear to think more critically and carefully during problem-solving activities and ask relevant questions so as to gather as much information as possible before proceeding.

Implications

Many NSF projects are specifically devoted to interventions that are designed to improve the teaching and learning of science, yet there remains incredible resistance to change. The question that science faculty must confront is whether we can afford to cram content at the expense of the development of scientific skills and thinking, and continue to let grading practices reflect previous preparation rather than actual learning in the classroom. With increased interest in STEM among entering students, the U.S. is at a critical crossroads in an opportunity to improve the production of science degrees. In order to move forward most productively, faculty must reexamine current practices.

Institutional researchers may assist in this reexamination by helping science faculty to broaden their assessment of student performance, employing varied ways of assessing student skills, and using multiple measures to evaluate existing programs. Currently, the vast majority of students are still in large lecture venues in introductory science and mathematics courses. Further research is needed to understand the impact of more varied and engaging pedagogies used by faculty in science. Investments made in these areas are necessary to open the valve for the movement of current students who will expand and diversify the scientific workforce.

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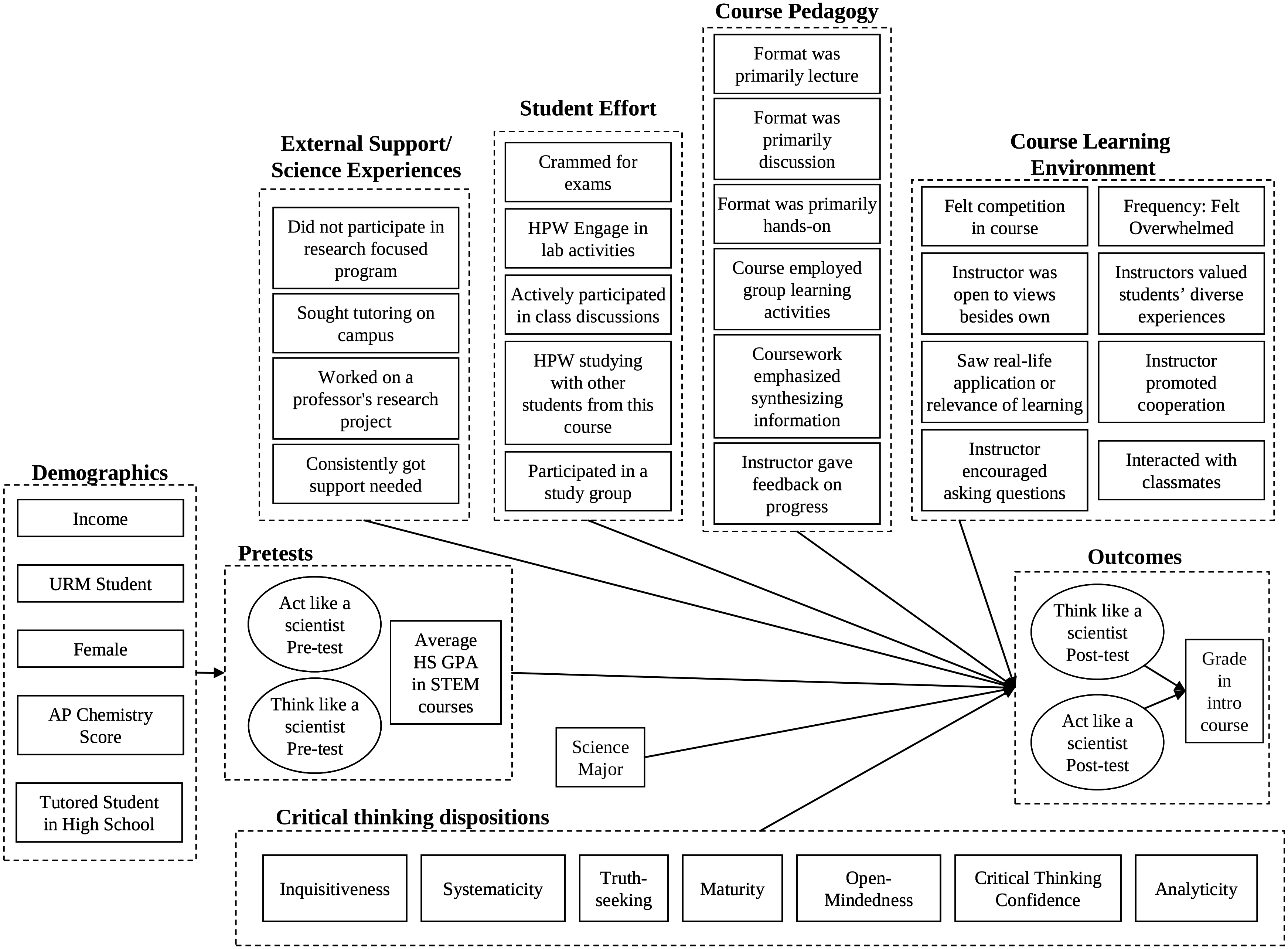
Demographics
Income
URM Student
Female
AP Chemistry Score
Tutored Student in High School
Pretests
Act like a scientist Pre-test
Think like a scientist Pre-test
Average HS GPA in STEM courses
External Support/ Science Experiences
Did not participate in research focused program
Sought tutoring on campus
Worked on a professor's research project
Consistently got support needed
Student Effort
Crammed for exams
HPW Engage in lab activities
Actively participated in class discussions
HPW studying with other students from this course
Participated in a study group
Course Pedagogy
Format was primarily lecture
Format was primarily discussion
Format was primarily hands-on
Course employed group learning activities
Coursework emphasized synthesizing information
Instructor gave feedback on progress
Course Learning Environment
Felt competition in course
Frequency: Felt Overwhelmed
Instructor was open to views besides own
Instructors valued students’ diverse experiences
Saw real-life application or relevance of learning
Instructor promoted cooperation
Instructor encouraged asking questions
Interacted with classmates
Science Major
Outcomes
Think like a scientist Post-test
Act like a scientist Post-test
Grade in intro course
Critical thinking dispositions
Inquisitiveness
Systematicity
Truth-seeking
Maturity
Open-Mindedness
Critical Thinking Confidence
Analyticity

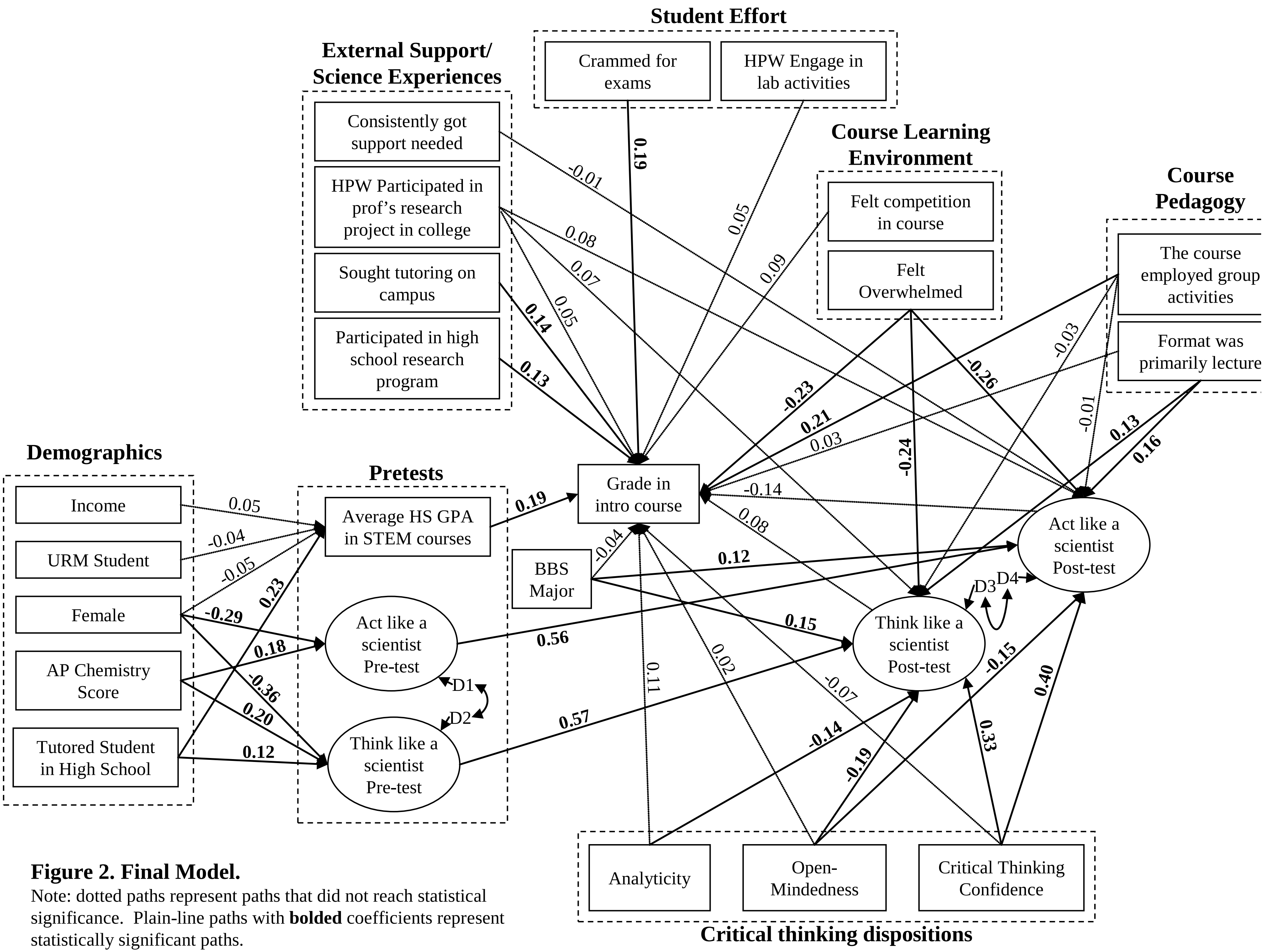

Figure 2. Final Model.
Note: dotted paths represent paths that did not reach statistical significance. Plain-line paths with **bolded** coefficients represent statistically significant paths.

Table 1

Factor Loadings for the latent constructs in the model

Factor	Items*	Loading
Thinking like a scientist pre-test		
	See connections between different areas of science and mathematics	0.78
	Understand scientific concepts	0.77
	Identify what is known and not known in a problem	0.72
	Ask relevant questions	0.72
	Draw a picture to represent a problem or concept	0.66
	Make predictions based on existing knowledge	0.75
	Come up with solutions and explain them to others	0.71
	Investigate alternative solutions to a problem	0.71
	Understand and translate scientific terminology into non-scientific language	0.74
Acting like a scientist pre-test		
	Relate scientific concepts to real-world problems	0.77
	Synthesize or comprehend several sources of information	0.85
	Conduct an experiment	0.64
	Look up scientific research articles and resources	0.60
	Memorize large quantities of information	0.61
Thinking like a scientist post-test		
	See connections between different areas of science and mathematics	0.73
	Understand scientific concepts	0.80
	Identify what is known and not known in a problem	0.76
	Ask relevant questions	0.72
	Draw a picture to represent a problem or concept	0.58
	Make predictions based on existing knowledge	0.82
	Come up with solutions and explain them to others	0.81
	Investigate alternative solutions to a problem	0.73
	Understand and translate scientific terminology into non-scientific language	0.72
Acting like a scientist post-test		
	Relate scientific concepts to real-world problems	0.80
	Synthesize or comprehend several sources of information	0.78
	Conduct an experiment	0.71
	Look up scientific research articles and resources	0.62
	Memorize large quantities of information	0.53

Measurement model fit statistics: X^2=300.69 (305, N=255), NNFI = 0.98, CFI = 0.98, RMSEA = 0.03, reliability coefficient = 0.82.

*Note: All items were asked as part of a questions stem that read, “Rate your ability in the following areas as it pertains to your academic learning in the sciences.” Response options were Major Strength (5), Above Average (4), Average (3), Below Average (2), Major Weakness (1).

Table 2

Parameter estimates for direct effects in the structural model

Endogenous variable	Predictor variables	b	B	S.E.	Sig	R^2
Average high school math/science GPA						0.06
	Parental income	0.01	0.05	0.01		
	Frequency: Tutored another student	0.13	0.23	0.04	**	
	Gender: Female	-0.04	-0.05	0.05		
	Race: Underrepresented racial minority student	-0.04	-0.04	0.05		
Acting like a scientist pre-test						0.12
	AP Chemistry score	0.07	0.18	0.03	*	
	Gender: Female	-0.43	-0.29	0.11	**	
Thinking like a scientist pre-test						0.18
	AP Chemistry score	0.07	0.20	0.02	*	
	Frequency: Tutored another student	0.11	0.12	0.04	*	
	Gender: Female	-0.47	-0.36	0.09	**	
Course grade						0.22
	Average high school math/science GPA	1.88	0.19	0.62	*	
	Thinking like a scientist post-test	0.58	0.08	1.79		
	Acting like a scientist post-test	-0.94	-0.14	1.74		
	Participated in a high school research program	1.80	0.13	0.84	*	
	CCTDI Openmindedness	0.01	0.02	0.04		
	CCTDI Analyticity	0.09	0.11	0.07		
	CCTDI Critical thinking confidence	-0.04	-0.07	0.05		
	Course pedagogy: primarily lecture	0.18	0.03	0.43		
	Course pedagogy: group work employed	0.85	0.21	0.30	*	
	Opinion: felt competition among students	0.37	.0.09	0.28		
	Opinion: felt overwhelmed by course expectations	-0.96	-0.23	0.30	**	
	Activity: Sought tutoring	0.49	0.14	0.23	*	
	Activity: Crammed for exams	0.78	0.19	0.26	**	
	Hours per week spent in lab	0.10	0.05	0.16		
	Activity: Participated in college research program	0.07	0.05	0.08		
	Major: biomedical or behavioral science	-0.30	-0.04	0.51		
Thinking like a scientist post-test						0.61
	Thinking like a scientist pre-test	0.47	0.57	0.06	***	
	CCTDI Openmindedness	-0.02	-0.19	0.01	**	
	CCTDI Analyticity	0.02	0.14	0.01	*	
	CCTDI Critical thinking confidence	0.02	0.33	0.01	**	
	Course pedagogy: primarily lecture	0.12	0.13	0.05	*	
	Course pedagogy: group work employed	-0.02	-0.03	0.03		
	Opinion: felt overwhelmed by course expectations	-0.14	-0.24	0.03	**	
	Activity: Participated in college research program	0.01	0.07	0.01		
	Major: biomedical or behavioral science	0.17	0.15	0.06	*	

N=255; χ^2 = 1,285.69 (1,050, $p < 0.001$); NNFI = 0.91, CFI = 0.92, RMSEA = 0.03

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2 (Continued)

Parameter estimates for direct effects in the structural model

Endogenous variable	Predictor variables	b	B	S.E.	Sig	R^2
Acting like a scientist post-test						0.60
	Acting like a scientist pre-test	0.43	0.56	0.06	***	
	CCTDI Openmindedness	-0.01	-0.15	0.01	*	
	CCTDI Critical thinking confidence	0.03	0.40	0.01	**	
	Course pedagogy: primarily lecture	0.15	0.16	0.06	*	
	Course pedagogy: group work employed	-0.01	-0.01	0.04		
	Opinion: felt overwhelmed by course expectations	-0.16	-0.26	0.03	**	
	Course pedagogy: received the support necessary	-0.01	-0.01	0.03		
	Activity: Participated in college research program	0.02	0.08	0.01		
	Major: biomedical or behavioral science	0.14	0.12	0.06	*	

N=255; χ^2 = 1,285.69 (1,050, $p < 0.001$); NNFI = 0.91, CFI = 0.92, RMSEA = 0.03

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3

Parameter estimates of indirect effects

Outcome	Predictor variable	b	B	S.E.	Sig.
Course grade					
	Acting like a scientist pre-test	-0.77	-0.14	0.72	
	Thinking like a scientist pre-test	0.69	0.11	0.79	
	Parental income	0.01	0.01	0.02	
	AP chemistry score	-0.01	0.00	0.02	
	CCTDI: Openmindedness	0.00	0.00	0.01	
	CCTDI: Analyticity	0.02	0.03	0.03	
	CCTDI: Critical thinking self-confidence	-0.02	-0.04	0.02	
	Activity: Tutored another student in high school	0.31	0.06	0.13	*
	Course pedagogy: Primarily lecture	-0.10	0.02	0.11	
	Course pedagogy: group work encouraged	-0.01	-0.01	0.05	
	Opinion: felt overwhelmed by course expectations	0.08	0.02	0.09	
	Course pedagogy: received the support necessary	0.02	0.00	0.06	
	Activity: Participated in college research program	-0.01	-0.01	0.02	
	Gender: Female	-0.07	-0.01	0.16	
	Major: Biomedical or behavioral science	0.00	0.00	0.12	
	Race: Underrepresented racial minority	-0.06	-0.01	0.10	
Thinking like a scientist post-test					
	AP chemistry score	0.03	0.11	0.01	*
	Activity: Tutored another student in high school	0.05	0.07	0.02	*
	Gender: Female	-0.22	-0.21	0.05	*
Acting like a scientist post-test					
	AP chemistry score	0.03	0.10	0.01	*
	Gender: Female	-0.18	-0.16	0.05	*

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix A: Variables in Initial Model and Coding

Variable	Coding
Demographics	
Income	1=Less than $20K to 8=More than $200K
URM Student	1 = Black, Chicano or Native American; 0 = White/Asian
Female	1 = Female, 0 = Male
AP Chemistry Score	1 to 5
Tutored Another student in High School	1 = Never, 2 = Occasionally, 3 = Frequently
BBS Major	1 = Biomedical or Behavioral Science Major, 0 = Other/Undecided
Pre-Tests	
Average HS GPA in STEM Courses	1 = D/F, 2 = C, 3 = B, 4 = A
External Support/Science Experiences	
Participated in a research-focused program during high school	1 = No, 0 = Yes
Sought tutoring on campus	1=Never, 2 = At least once, 3 = Occasionally, 4=Almost always
Participated in a research project	
Working on a professor's research project (Hours per week during term)	1 = Zero hours to 13=More than 10 hours
Consistently received the support needed to do well	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Student Effort	
Crammed For Exams	1=Never, 2 = At least once, 3 = Occasionally, 4=Almost always
Actively participated in class discussions	1=Never, 2 = At least once, 3 = Occasionally, 4=Almost always
Participated in a study group	1=Never, 2 = At least once, 3 = Occasionally, 4=Almost always
Studied with other students from this course (Hours per week during term)	1 = Zero hours to 13=More than 10 hours
Engaged in lab activities (Hours per week during term)	1 = Zero hours to 13=More than 10 hours
Course Pedagogy	
The format of this course was primarily lecture	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
The format of this course was primarily discussion	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
The format of this course was primarily hands-on activity	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
The course employed group activities to foster learning	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree

The coursework emphasized synthesizing and organizing ideas and information	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Instructor gave students feedback on their performance or progress in the course	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Course Learning Environment	
I frequently experienced a high level of competition among students	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
I felt overwhelmed by what was expected of me for this course	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Instructor appeared open to viewpoints besides his/her own	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Instructor valued students' diverse life experiences	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
I saw the real-life application or relevance of what I learned	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Instructor promoted cooperation among students	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Instructor encouraged students to ask questions	1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree
Interacted with classmates	1=Never, 2 = At least once, 3 = Occasionally, 4=Almost always
Critical Thinking Dispositions (See Facione, Sanchez, and Facione (1993) for more details)	
Inquisitiveness	10 to 60
Systematicity	10 to 60
Truth-seeking	10 to 60
Maturity	10 to 60
Open-Mindedness	10 to 60
Critical Thinking Confidence	10 to 60
Analyticity	10 to 60
Outcomes	
Grade in intro Course	9 = A+, 8 = A, 7 = A-, 6 = B+, 5 = B, 4 = B-, 3 = C+, 2 = C, 1 = C- or below

Appendix B: Descriptive statistics for variables in the model

	Mean	S.D.	Min.	Max
Parental income	5.03	2.19	1	8
AP chemistry score	2.05	1.83	0	6
Openmindedness	41.29	6.27	22	58
Analyticity	43.00	4.99	28	60
Critical thinking self-confidence	42.43	7.06	20	60
Course grade	6.78	3.80	0	12
Average grade in high school math and science courses	3.71	0.37	1	4
Participated in a pre-college research program	0.08	0.27	0	1
Tutored another stuent in high school	1.98	0.66	1	3
Pedagogy: course was primarily lecture	3.67	0.56	1	4
Pedagogy: course encouraged group activities	1.98	0.93	1	4
Opinion: Competition among students for grades	2.90	0.91	1	4
Opinion: Felt overwhelmed by course expectations	2.40	0.93	1	4
Opinion: Consistently received the support I needed	2.80	0.60	1	4
Sought out tutoring from a campus office or program	3.27	1.06	1	4
Crammed for exams	2.03	0.90	1	4
Engaging in laboratory activities	1.88	1.66	1	8
Participating in a science research program in college	2.06	2.76	1	13
Gender: Female	0.75	0.48	0	1
Major: Biomedical or behavioral science	0.23	0.48	0	1
Race: underrepresented racial minority	0.29	0.45	0	1

Source: Descriptive analysis of pre- and post-survey data.

Appendix C: Correlation table for all variables in the model

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	See connections between different areas of science and mathematics (pre-test)	1.00												
2	Understand scientific concepts (pre-test)	0.69	1.00											
3	Relate scientific concepts to real-world problems (pre-test)	0.54	0.68	1.00										
4	Synthesize or comprehend several sources of information (pre-test)	0.57	0.61	0.66	1.00									
5	Identify what is known and not known in a problem (pre-test)	0.57	0.58	0.49	0.50	1.00								
6	Ask relevant questions (pre-test)	0.56	0.57	0.52	0.51	0.62	1.00							
7	Draw a picture to represent a problem or concept (pre-test)	0.48	0.46	0.45	0.47	0.49	0.62	1.00						
8	Make predictions based on existing knowledge (pre-test)	0.60	0.58	0.53	0.57	0.53	0.55	0.60	1.00					
9	Conduct an experiment (pre-test)	0.47	0.52	0.48	0.55	0.44	0.42	0.44	0.64	1.00				
10	Come up with solutions and explain them to others (pre-test)	0.58	0.50	0.43	0.60	0.44	0.55	0.50	0.54	0.47	1.00			
11	Investigate alternative solutions to a problem (pre-test)	0.51	0.49	0.52	0.56	0.45	0.55	0.51	0.60	0.50	0.67	1.00		
12	Look up scientific research articles and resources (pre-test)	0.34	0.36	0.46	0.51	0.31	0.32	0.28	0.38	0.38	0.22	0.45	1.00	
13	Memorize large quantities of information (pre-test)	0.44	0.36	0.44	0.53	0.35	0.40	0.28	0.43	0.34	0.37	0.33	0.40	1.00
14	Understand and translate scientific terminology into non-scientific language (pre-test)	0.58	0.54	0.55	0.61	0.53	0.49	0.49	0.50	0.43	0.57	0.50	0.34	0.49
15	Parental income	-0.01	-0.05	-0.11	0.04	-0.13	-0.11	-0.15	-0.09	-0.13	-0.02	-0.12	-0.10	-0.03
16	AP chemistry score	0.17	0.15	0.08	0.20	0.17	0.12	0.04	0.07	0.13	0.14	0.10	0.02	0.08
17	See connections between different areas of science and mathematics (post-test)	0.53	0.55	0.44	0.44	0.47	0.47	0.38	0.45	0.39	0.30	0.35	0.33	0.34
18	Understand scientific concepts (post-test)	0.59	0.53	0.50	0.48	0.44	0.49	0.36	0.42	0.37	0.36	0.44	0.30	0.42
19	Relate scientific concepts to real-world problems (post-test)	0.45	0.47	0.54	0.49	0.42	0.41	0.31	0.41	0.40	0.32	0.43	0.33	0.40
20	Synthesize or comprehend several sources of information (post-test)	0.44	0.43	0.47	0.48	0.40	0.44	0.27	0.40	0.39	0.34	0.43	0.30	0.35
21	Identify what is known and not known in a problem (post-test)	0.52	0.46	0.48	0.44	0.45	0.47	0.39	0.42	0.38	0.36	0.39	0.28	0.41
22	Ask relevant questions (post-test)	0.40	0.39	0.39	0.40	0.36	0.52	0.34	0.42	0.33	0.33	0.37	0.23	0.34
23	Draw a picture to represent a problem or concept (post-test)	0.43	0.29	0.25	0.36	0.30	0.38	0.52	0.32	0.24	0.33	0.25	0.21	0.27
24	Make predictions based on existing knowledge (post-test)	0.49	0.46	0.50	0.52	0.35	0.48	0.41	0.53	0.50	0.45	0.48	0.32	0.43
25	Conduct an experiment (post-test)	0.43	0.47	0.49	0.46	0.39	0.41	0.38	0.56	0.59	0.39	0.48	0.44	0.39
26	Come up with solutions and explain them to others (post-test)	0.51	0.50	0.45	0.46	0.40	0.42	0.39	0.41	0.40	0.47	0.43	0.30	0.27
27	Investigate alternative solutions to a problem (post-test)	0.38	0.38	0.40	0.45	0.37	0.44	0.42	0.51	0.43	0.36	0.53	0.39	0.33
28	Look up scientific research articles and resources (post-test)	0.31	0.24	0.34	0.33	0.27	0.30	0.26	0.34	0.29	0.09	0.28	0.65	0.30
29	Memorize large quantities of information (post-test)	0.33	0.26	0.34	0.30	0.20	0.27	0.19	0.32	0.26	0.25	0.26	0.33	0.60
30	Understand and translate scientific terminology into non-scientific language (post-test)	0.42	0.32	0.33	0.37	0.25	0.27	0.27	0.33	0.31	0.31	0.35	0.25	0.30
31	Openmindedness	-0.06	-0.04	-0.05	0.04	0.00	-0.05	-0.13	-0.02	-0.02	0.02	-0.04	-0.08	-0.14
32	Analyticity	0.28	0.32	0.34	0.30	0.25	0.26	0.24	0.34	0.33	0.30	0.32	0.17	0.12
33	Critical thinking self-confidence	0.31	0.30	0.44	0.46	0.32	0.34	0.29	0.41	0.40	0.38	0.47	0.29	0.25
34	Course grade	0.11	0.11	0.11	0.07	0.18	0.04	-0.07	0.00	-0.01	0.04	0.06	0.01	0.05
35	Average grade in high school math and science courses	0.15	0.11	0.01	0.13	0.07	0.01	-0.03	0.01	0.01	0.07	0.07	0.11	0.07
36	Participated in a pre-college research program	-0.04	-0.08	-0.03	0.08	0.01	-0.07	0.04	-0.05	0.01	-0.03	0.01	0.10	-0.06
37	Tutored another stuent in high school	0.15	0.14	0.04	0.15	0.21	0.14	0.19	0.05	0.08	0.18	0.22	0.17	-0.07
38	Pedagogy: course was primarily lecture	0.14	0.13	0.07	0.13	0.05	-0.01	0.02	0.05	0.04	0.05	0.07	0.10	0.09
39	Pedagogy: course encouraged group activities	-0.02	0.01	0.07	-0.07	0.05	0.07	0.05	0.06	0.03	0.01	0.07	0.04	-0.01
40	Opinion: Competition among students for grades	-0.08	-0.08	-0.08	-0.09	0.02	0.11	0.04	0.03	0.03	0.09	0.05	-0.08	0.09
41	Opinion: Felt overwhelmed by course expectations	-0.21	-0.17	-0.09	-0.11	-0.19	-0.12	-0.04	-0.09	0.00	-0.04	-0.08	-0.09	-0.04
42	Opinion: Consistently received the support I needed	0.18	0.14	0.17	0.12	0.18	0.12	0.11	0.11	0.13	0.13	0.09	0.13	0.11
43	Sought out tutoring from a campus office or program	0.15	0.04	-0.08	0.01	0.03	-0.07	-0.05	-0.03	-0.08	-0.06	-0.06	-0.12	0.00
44	Crammed for exams	0.08	0.13	0.09	0.09	0.14	0.06	0.05	-0.08	-0.04	0.01	0.04	0.12	0.05
45	Engaging in laboratory activities	-0.05	-0.01	0.05	0.03	0.01	0.07	0.02	0.12	0.10	-0.06	0.00	0.21	0.10
46	Participating in a science research program in college	0.11	0.11	0.12	0.12	0.03	0.08	0.08	0.08	0.15	0.08	0.18	0.27	0.06
47	Gender: Female	-0.27	-0.22	-0.22	-0.26	-0.17	-0.15	-0.25	-0.35	-0.18	-0.36	-0.35	-0.11	-0.22
48	Major: Biomedical or behavioral science	-0.12	-0.17	-0.07	-0.05	-0.08	-0.02	-0.11	0.02	-0.02	-0.09	-0.10	0.08	0.10
49	Race: underrepresented racial minority	0.01	0.08	-0.03	0.03	0.00	-0.01	0.05	0.03	0.16	-0.02	0.06	-0.01	0.03

Appendix C (continued): Correlation table for all variables in the model

		14	15	16	17	18	19	20	21	22	23	24	25	26
1	See connections between different areas of science and mathematics (pre-test)													
2	Understand scientific concepts (pre-test)													
3	Relate scientific concepts to real-world problems (pre-test)													
4	Synthesize or comprehend several sources of information (pre-test)													
5	Identify what is known and not known in a problem (pre-test)													
6	Ask relevant questions (pre-test)													
7	Draw a picture to represent a problem or concept (pre-test)													
8	Make predictions based on existing knowledge (pre-test)													
9	Conduct an experiment (pre-test)													
10	Come up with solutions and explain them to others (pre-test)													
11	Investigate alternative solutions to a problem (pre-test)													
12	Look up scientific research articles and resources (pre-test)													
13	Memorize large quantities of information (pre-test)													
14	Understand and translate scientific terminology into non-scientific language (pre-test)	1.00												
15	Parental income	-0.03	1.00											
16	AP chemistry score	0.14	0.02	1.00										
17	See connections between different areas of science and mathematics (post-test)	0.40	-0.12	0.11	1.00									
18	Understand scientific concepts (post-test)	0.43	-0.12	0.12	0.72	1.00								
19	Relate scientific concepts to real-world problems (post-test)	0.39	-0.03	0.09	0.67	0.71	1.00							
20	Synthesize or comprehend several sources of information (post-test)	0.36	-0.03	0.07	0.52	0.67	0.66	1.00						
21	Identify what is known and not known in a problem (post-test)	0.45	-0.10	0.09	0.56	0.60	0.56	0.58	1.00					
22	Ask relevant questions (post-test)	0.30	-0.07	-0.01	0.51	0.56	0.50	0.52	0.59	1.00				
23	Draw a picture to represent a problem or concept (post-test)	0.33	-0.07	0.06	0.43	0.48	0.40	0.40	0.45	0.48	1.00			
24	Make predictions based on existing knowledge (post-test)	0.43	-0.13	0.10	0.55	0.64	0.59	0.65	0.60	0.60	0.50	1.00		
25	Conduct an experiment (post-test)	0.36	-0.11	-0.08	0.46	0.52	0.57	0.53	0.46	0.43	0.33	0.60	1.00	
26	Come up with solutions and explain them to others (post-test)	0.43	-0.09	0.08	0.60	0.63	0.57	0.61	0.56	0.58	0.43	0.66	0.59	1.00
27	Investigate alternative solutions to a problem (post-test)	0.41	-0.16	0.03	0.52	0.51	0.54	0.53	0.51	0.55	0.32	0.62	0.65	0.71
28	Look up scientific research articles and resources (post-test)	0.22	-0.14	-0.05	0.41	0.41	0.51	0.45	0.37	0.40	0.34	0.43	0.55	0.46
29	Memorize large quantities of information (post-test)	0.26	-0.11	-0.12	0.39	0.46	0.42	0.38	0.42	0.47	0.35	0.46	0.37	0.39
30	Understand and translate scientific terminology into non-scientific language (post-test)	0.53	-0.04	-0.01	0.45	0.56	0.56	0.50	0.58	0.49	0.40	0.49	0.48	0.60
31	Openmindedness	0.01	0.14	0.02	-0.15	-0.13	-0.09	0.03	-0.02	0.02	-0.07	-0.11	-0.16	-0.06
32	Analyticity	0.23	-0.04	0.05	0.34	0.36	0.34	0.31	0.27	0.38	0.23	0.38	0.25	0.40
33	Critical thinking self-confidence	0.34	-0.02	0.03	0.41	0.45	0.46	0.49	0.34	0.41	0.32	0.51	0.42	0.53
34	Course grade	0.04	0.10	0.10	0.12	0.10	0.09	0.03	0.08	0.03	-0.02	0.04	-0.06	0.02
35	Average grade in high school math and science courses	0.05	0.06	0.22	0.11	0.17	0.10	0.10	0.01	0.11	0.06	0.13	-0.04	0.11
36	Participated in a pre-college research program	0.08	0.08	0.15	-0.01	-0.13	0.07	-0.10	-0.05	-0.11	-0.10	-0.07	-0.09	-0.11
37	Tutored another stuent in high school	0.21	-0.02	0.07	0.14	0.08	0.07	0.09	0.08	0.12	0.13	0.04	0.05	0.18
38	Pedagogy: course was primarily lecture	0.08	0.10	0.01	0.04	0.16	0.17	0.16	0.15	0.08	0.09	0.09	0.12	0.07
39	Pedagogy: course encouraged group activities	-0.06	-0.17	-0.04	0.15	0.00	0.04	-0.03	0.04	-0.05	-0.10	0.12	0.11	0.03
40	Opinion: Competition among students for grades	-0.06	0.01	0.00	-0.04	-0.02	0.04	0.02	0.05	0.00	-0.05	0.01	0.04	-0.10
41	Opinion: Felt overwhelmed by course expectations	-0.14	0.01	-0.07	-0.19	-0.21	-0.20	-0.17	-0.19	-0.25	-0.14	-0.19	-0.11	-0.21
42	Opinion: Consistently received the support I needed	0.17	0.00	0.08	0.23	0.22	0.12	0.13	0.19	0.11	0.14	0.16	0.14	0.21
43	Sought out tutoring from a campus office or program	0.09	0.14	0.15	0.04	0.07	0.10	0.03	0.15	0.00	0.18	0.03	-0.06	-0.06
44	Crammed for exams	0.13	-0.04	-0.05	0.07	0.10	0.11	0.09	0.07	0.07	0.06	-0.04	0.01	0.10
45	Engaging in laboratory activities	-0.07	-0.16	-0.10	0.15	0.02	0.05	-0.03	0.13	0.09	0.00	0.13	0.20	-0.01
46	Participating in a science research program in college	-0.01	0.01	0.03	0.20	0.19	0.21	0.17	0.12	0.08	0.16	0.15	0.11	0.15
47	Gender: Female	-0.23	0.03	0.01	-0.19	-0.19	-0.25	-0.14	-0.18	-0.26	-0.14	-0.28	-0.21	-0.26
48	Major: Biomedical or behavioral science	-0.09	-0.09	-0.24	-0.08	-0.07	-0.05	0.00	0.04	0.05	0.03	0.02	0.06	-0.07
49	Race: underrepresented racial minority	0.04	-0.19	-0.12	0.12	0.07	0.05	-0.10	0.01	0.08	0.04	0.11	0.14	0.08

Appendix C (continued): Correlation table for all variables in the model

		27	28	29	30	31	32	33	34	35	36	37	38	39
1	See connections between different areas of science and mathematics (pre-test)													
2	Understand scientific concepts (pre-test)													
3	Relate scientific concepts to real-world problems (pre-test)													
4	Synthesize or comprehend several sources of information (pre-test)													
5	Identify what is known and not known in a problem (pre-test)													
6	Ask relevant questions (pre-test)													
7	Draw a picture to represent a problem or concept (pre-test)													
8	Make predictions based on existing knowledge (pre-test)													
9	Conduct an experiment (pre-test)													
10	Come up with solutions and explain them to others (pre-test)													
11	Investigate alternative solutions to a problem (pre-test)													
12	Look up scientific research articles and resources (pre-test)													
13	Memorize large quantities of information (pre-test)													
14	Understand and translate scientific terminology into non-scientific language (pre-test)													
15	Parental income													
16	AP chemistry score													
17	See connections between different areas of science and mathematics (post-test)													
18	Understand scientific concepts (post-test)													
19	Relate scientific concepts to real-world problems (post-test)													
20	Synthesize or comprehend several sources of information (post-test)													
21	Identify what is known and not known in a problem (post-test)													
22	Ask relevant questions (post-test)													
23	Draw a picture to represent a problem or concept (post-test)													
24	Make predictions based on existing knowledge (post-test)													
25	Conduct an experiment (post-test)													
26	Come up with solutions and explain them to others (post-test)													
27	Investigate alternative solutions to a problem (post-test)	1.00												
28	Look up scientific research articles and resources (post-test)	0.51	1.00											
29	Memorize large quantities of information (post-test)	0.47	0.44	1.00										
30	Understand and translate scientific terminology into non-scientific language (post-test)	0.51	0.44	0.43	1.00									
31	Openmindedness	-0.11	-0.07	-0.12	0.00	1.00								
32	Analyticity	0.23	0.16	0.18	0.30	0.33	1.00							
33	Critical thinking self-confidence	0.46	0.32	0.29	0.37	0.07	0.59	1.00						
34	Course grade	0.06	-0.04	0.14	0.09	0.07	0.10	-0.02	1.00					
35	Average grade in high school math and science courses	0.16	0.10	0.07	0.10	0.04	0.03	0.02	0.27	1.00				
36	Participated in a pre-college research program	-0.03	0.01	-0.09	0.06	0.08	-0.03	0.03	0.16	0.11	1.00			
37	Tutored another stuent in high school	0.12	0.09	0.00	0.06	0.14	0.10	0.13	0.02	0.22	-0.05	1.00		
38	Pedagogy: course was primarily lecture	0.07	0.04	0.17	0.20	0.06	0.02	-0.02	0.01	0.00	-0.06	0.01	1.00	
39	Pedagogy: course encouraged group activities	0.11	0.02	-0.02	-0.15	-0.30	-0.07	0.14	0.10	-0.05	0.01	0.01	-0.25	1.00
40	Opinion: Competition among students for grades	0.01	-0.11	0.00	-0.14	-0.11	-0.03	0.02	-0.09	-0.15	0.11	-0.07	0.09	0.17
41	Opinion: Felt overwhelmed by course expectations	-0.18	-0.21	-0.16	-0.22	-0.19	-0.17	0.01	-0.29	-0.22	-0.03	-0.16	0.03	0.19
42	Opinion: Consistently received the support I needed	0.10	0.15	0.14	0.06	-0.09	0.08	0.17	0.07	0.03	0.04	0.06	-0.08	0.31
43	Sought out tutoring from a campus office or program	-0.10	-0.05	0.00	0.12	0.14	0.02	-0.12	0.17	0.07	-0.07	-0.07	0.18	-0.24
44	Crammed for exams	0.07	0.10	0.02	0.09	0.02	-0.06	-0.05	0.22	0.12	-0.10	0.12	0.01	-0.02
45	Engaging in laboratory activities	0.16	0.20	0.18	0.01	-0.19	0.05	0.06	0.11	0.00	-0.07	-0.04	-0.12	0.46
46	Participating in a science research program in college	0.14	0.25	0.14	0.13	-0.05	0.01	0.14	0.10	0.18	0.01	0.06	0.09	-0.02
47	Gender: Female	-0.30	-0.08	-0.25	-0.21	0.08	-0.20	-0.21	0.01	-0.06	-0.06	0.04	-0.05	0.01
48	Major: Biomedical or behavioral science	0.08	0.06	0.22	-0.02	-0.07	-0.22	-0.06	-0.12	-0.22	0.11	-0.15	-0.01	0.18
49	Race: underrepresented racial minority	0.12	0.07	0.11	0.10	-0.07	0.15	0.09	-0.14	-0.04	0.01	0.07	-0.06	0.10

Appendix C (continued): Correlation table for all variables in the model

		40	41	42	43	44	45	46	47	48	49
1	See connections between different areas of science and mathematics (pre-test)										
2	Understand scientific concepts (pre-test)										
3	Relate scientific concepts to real-world problems (pre-test)										
4	Synthesize or comprehend several sources of information (pre-test)										
5	Identify what is known and not known in a problem (pre-test)										
6	Ask relevant questions (pre-test)										
7	Draw a picture to represent a problem or concept (pre-test)										
8	Make predictions based on existing knowledge (pre-test)										
9	Conduct an experiment (pre-test)										
10	Come up with solutions and explain them to others (pre-test)										
11	Investigate alternative solutions to a problem (pre-test)										
12	Look up scientific research articles and resources (pre-test)										
13	Memorize large quantities of information (pre-test)										
14	Understand and translate scientific terminology into non-scientific language (pre-test)										
15	Parental income										
16	AP chemistry score										
17	See connections between different areas of science and mathematics (post-test)										
18	Understand scientific concepts (post-test)										
19	Relate scientific concepts to real-world problems (post-test)										
20	Synthesize or comprehend several sources of information (post-test)										
21	Identify what is known and not known in a problem (post-test)										
22	Ask relevant questions (post-test)										
23	Draw a picture to represent a problem or concept (post-test)										
24	Make predictions based on existing knowledge (post-test)										
25	Conduct an experiment (post-test)										
26	Come up with solutions and explain them to others (post-test)										
27	Investigate alternative solutions to a problem (post-test)										
28	Look up scientific research articles and resources (post-test)										
29	Memorize large quantities of information (post-test)										
30	Understand and translate scientific terminology into non-scientific language (post-test)										
31	Openmindedness										
32	Analyticity										
33	Critical thinking self-confidence										
34	Course grade										
35	Average grade in high school math and science courses										
36	Participated in a pre-college research program										
37	Tutored another stuent in high school										
38	Pedagogy: course was primarily lecture										
39	Pedagogy: course encouraged group activities										
40	Opinion: Competition among students for grades	1.00									
41	Opinion: Felt overwhelmed by course expectations	0.44	1.00								
42	Opinion: Consistently received the support I needed	0.05	-0.13	1.00							
43	Sought out tutoring from a campus office or program	-0.15	-0.28	-0.11	1.00						
44	Crammed for exams	-0.15	-0.15	0.10	-0.08	1.00					
45	Engaging in laboratory activities	0.05	-0.02	0.19	-0.17	-0.05	1.00				
46	Participating in a science research program in college	-0.10	-0.09	0.08	0.04	0.08	-0.01	1.00			
47	Gender: Female	0.06	0.09	0.04	0.05	0.05	0.07	-0.13	1.00		
48	Major: Biomedical or behavioral science	0.22	0.17	0.05	-0.18	-0.09	0.18	-0.09	0.10	1.00	
49	Race: underrepresented racial minority	-0.12	-0.08	-0.01	0.09	-0.07	0.14	-0.05	-0.04	-0.01	1.00