Intellectual development is positively related to intrinsic motivation and course grades for female but not male students

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EPISTEMOLOGICAL BELIEFS and intellectual development are the attitudes and assumptions that individuals hold about the nature of knowledge and learning (17, 32). These attitudes and assumptions have a profound effect on how students construct and integrate knowledge and, ultimately, understand their world. Individuals advance through stages of progressively more mature or sophisticated levels of intellectual development (3, 25). For example, individuals can view the nature of knowledge as simple or complex, absolute or tentative (32, 34). Similarly, they can view the foundation of knowledge as authoritarian or reasoned, either quick to grasp or gradual, fixed or something that can be improved over time (32, 34). It seems likely that individuals with lower levels of intellectual development are less able to work with ambiguity and uncertainty.

In a similar manner, students advance through stages of progressively more mature or sophisticated levels of motivation. Most mature or sophisticated learning occurs when students have intrinsic motivation and personal interest in the material (24). These students with the highest intrinsic motivation search for meaning and general concepts while making links with previous knowledge. Less mature and sophisticated learning occurs when students have lower levels of intrinsic motivation and are motivated externally to be successful. These students focus on examinable material, and as expected, their knowledge is limited and patchy (24).

We recently documented the influence of sex (female vs. male) on class attendance and examination performance (6) as well as learning style preference (37, 41) and levels of intrinsic motivation (5). These studies suggested that sex differences may be rooted in evolutionary biology and/or overwhelming social differences. Accordingly, it seems likely that sex (and perhaps intellectual development) also influences motivational stages.

Accordingly, we hypothesized that the intellectual development of students, i.e., their beliefs about the nature of knowledge and learning, is associated with their intrinsic motivation and class performance. Specifically, we hypothesized that students with low intellectual development (i.e., the naive beliefs that knowledge is simple, absolute, and certain) have low intrinsic motivation and low class performance, whereas students with high intellectual development (i.e., more sophisticated beliefs that knowledge is complex, tentative, and evolving) have high intrinsic motivation and high class performance.

To test this hypothesis, we administered the Learning Context Questionnaire (LCQ) to measure intellectual development. The LCQ was originally developed by Kelton and Griffith (18) to assess intellectual development. In addition, we administered the Intrinsic Motivation Inventory to assess our students’ intrinsic motivation. Furthermore, we performed regression analyses between intellectual development with both intrinsic motivation and class performance. The results document a positive relationship among intellectual development, intrinsic motivation, and class performance for female students only. In sharp contrast, there was a negative relationship between intellectual development, intrinsic motivation, and class performance for male students.

The slope comparisons documented significant differences in the slopes relating intellectual development, intrinsic motivation, and class performance between female and male students. Thus, female students with more sophisticated beliefs that knowledge is personally constructed, complex, and evolving had higher intrinsic motivation and class performance. In contrast, male students with the naive beliefs that the structure of knowledge is simple, absolute, and certain had higher levels of intrinsic motivation and class performance.

The results suggest that sex influences intellectual development, which has an effect on intrinsic motivation for learning a specific topic.
How We Teach: Generalizable Education Research

Methods

Performance. Class performance was determined by success on the IMI, a multidimensional measurement device developed by Deci and Ryan in 1991, to assess our students’ intrinsic motivation. The IMI instrument has been validated and used in several experiments related to intrinsic motivation and self-motivation. The IMI consists of 22 statements that a student recognizes as access to the IMI can be obtained at http://www.selfdeterminationtheory.org/questionnaires/10questionnaires/50.

Importantly, the rate at which we progress through the stages, and whether or not we progress to the highest stage, varies from individual to individual as we move from less to more complex reasoning. This progression occurs because, as many of us realize, life is more complex as older adults than as young adults. Accordingly, we mature and adapt to accommodate the complexity.

In addition, we administered the Intrinsic Motivation Inventory (IMI), a multidimensional measurement device developed by Deci and Ryan in 1991, to assess our students’ intrinsic motivation. The IMI instrument has been validated and used in several experiments related to intrinsic motivation and self-regulation. The instrument assesses students’ interest/enjoyment while performing a given activity. The interest/enjoyment subscale is considered the self-reported measure of intrinsic motivation. Additional information as well as access to the IMI can be obtained at http://www.selfdeterminationtheory.org/questionnaires/10questionnaires/50.

Finally, we performed regression analyses between intellectual development with intrinsic motivation and class performance. Class performance was determined by success on multiple-choice exams and the final grade in one large university class.

Male vs. Female Students

Fig. 1. Percentages of male and female students on all levels of intellectual development: dualist, multiplicity, relativism, and commitment. A higher percentage of male students were in the dualist stage (lowest level) compared with female students (22% vs. 2%, respectively). In contrast, this result was reversed for the next two higher stages of intellectual development (multiplicity: 67% for male students vs. 83% for female students and relativism: 11% for male students vs. 14% for female students). Neither male nor female students reached commitment, the highest level of intellectual development. *P ≤ 0.05, female vs. male students.

In addition, we administered the Intrinsic Motivation Inventory items used to determine a person’s level of intrinsic versus extrinsic motivation.

In addition, class attendance was recorded anonymously in each class using assigned, deidentified codes; however, it did not factor into the final grades. The final course grade was based on four 1-h multiple-choice examinations and a 2-h cumulative final multiple-choice examination.

Analysis. Descriptive statistics and means (SD) were calculated and are presented. In addition, a nonparametric Mann-Whitney test was used to determine sex differences (female vs. male) on class attendance and course grade. A Fisher’s exact test was performed to determine if significant sex differences exist between the four major stages of intellectual development: from dualism to multiplicity to relativism to commitment (Fig. 1). Subjects were categorized into the four levels of intellectual development based on the following scoring system: dualist, 0–88; multiplicity, 89–101; relativism, 102–114; and commitment, ≥115 (18).

Using GraphPad Prism 6, two separate linear regression analyses were performed between intellectual development and intrinsic motivation (Fig. 2) as well as intellectual development and course grade (Fig. 3) for male and female students to determine sex differences (female vs. male) on the association between intellectual development and course grade.
development score for female students was associated with an average increase of 0.1 points (the slope) in intrinsic motivation. In contrast, there was a small decrease in intrinsic motivation with an increase in intellectual development score for male students (Fig. 2). As male students’ intellectual development scores moved higher on the scale, their intrinsic motivation slightly decreased. Specifically, each increase in intellectual development score for male students was associated with an average decrease of 0.1 points (the slope) in intrinsic motivation. The slope comparison documented a significant difference ($P = 0.02$) in the slopes relating intellectual development and intrinsic motivation between female and male students. The confidence interval (the expected range for the true slope to fall within an interval 95% of the time) was $-0.159$ to $+0.035$ for male students and $-0.005$ to $+0.159$ for female students (Fig. 2).

Finally, there was a small increase in course grade with an increase in intellectual development score for female students (Fig. 3). Specifically, each increase in intellectual development score was associated with an average increase of 0.4% (the slope) in course grade. In contrast, there was a small decrease in course grade with an increase in intellectual development score for male students (Fig. 3). Specifically, each increase in intellectual development score was associated with an average decrease of 0.6% (the slope) in course grade. The slope comparison documented a significant difference ($P = 0.05$) in the slopes relating intellectual development and course grade between female and male students. The confidence interval was $-1.280$ to $+0.084$ for male students and $-0.348$ to $+1.050$ for female students.

**DISCUSSION**

In the present study, we used the LCQ to measure our students’ levels of intellectual development. Lower scores indicate more naïve beliefs about the nature of knowledge. Students with lower scores have the naïve beliefs that knowledge is acquired rapidly, is composed of isolated independent facts, is unconditional, and that students have a predetermined ability to learn. In contrast, students with higher scores have more sophisticated beliefs that knowledge is obtained gradually, is organized as highly intertwined concepts, is uncertain, and that students have the capability to improve their learning skills (34).

Intrinsic motivation includes actions and behaviors that are carried out voluntarily for personal self-fulfillment and may or may not produce material rewards (39, 40). In the present study, we also used the IMI to assess our students’ level of intrinsic motivation. Lower scores on the IMI indicate lower levels of intrinsic motivation and suggest a naïve level of understanding of concepts and principles as well as a failure to make connection with existing knowledge. In contrast, students with higher scores on the IMI have higher levels of intrinsic motivation and suggest a more sophisticated level of understanding (24).

Learning occurs when students have intrinsic motivation and personal interest in the educational material. This occurs because when students are intrinsically motivated, they search for meaning and general concepts and connect the new information with previous knowledge. Accordingly, it is not surprising that intrinsic motivation has the most positive impact on school

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**RESULTS**

Daily attendance for female students [mean: 80% (SD 20%)] was significantly higher than daily attendance for male students [mean: 66% (SD 23%)]. In contrast, there were no differences in examination scores between female and male students [mean: 82% (SD 11%) for female students and mean: 83% (SD 10%) for male students]. The class average for the present course was typical of previous class averages, based on instructor records (data not shown).

Figure 1 shows the influence of sex (female vs. male) on all levels of intellectual development. Specifically, a higher percentage of male students were in the dualist stage (lowest level) of the LCQ compared with female students (22% for male students vs. 2% for female students). In contrast, this result was reversed for the next two higher stages of intellectual development (multiplicity: 67% for male students vs. 83% for female students and relativism: 11% for male students and 14% for female students). Neither male nor female students reached commitment, the highest level of intellectual development. A Fisher’s exact test revealed that the two characteristics (female vs. male) were significantly related ($P = 0.05$).

As shown in Fig. 2, there was a small increase in intrinsic motivation with an increase in intellectual development score for female students. As female students’ intellectual development scores moved higher on the scale, their intrinsic motivation also increased. Specifically, each increase in intellectual development and intrinsic motivation as well as intellectual development and course grade. The regression equations and $R^2$ values are presented in each figure. GraphPad Prism 6 was also used to test for significant differences between slopes. The GraphPad Prism approach is equivalent to an analysis of covariance. Importantly, residual analyses demonstrated the regression models were appropriate. Statistical significance was established a priori as $P \leq 0.05$.

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Fig. 3. Regression analysis between intellectual development with class performance (course grade) in female and male students. There was a small increase in course grade with an increase in intellectual development score for female students. In contrast, there was a small decrease in course grade with an increase in intellectual development score for male students. The slopes relating intellectual development and course grade between female and male students were significantly different. $^*P \leq 0.05$, female vs. male students.
The results from this study suggest that female students are more likely to have higher intellectual development than male students (Fig. 1). Furthermore, female students had a positive relationship between intellectual development and intrinsic motivation (Fig. 2) as well as intellectual development and course grade (Fig. 3). In contrast, male students had a negative relationship between intellectual development and intrinsic motivation (Fig. 2) as well as intellectual development and course grade (Fig. 3). The slope comparisons documented significant differences in the slopes relating intellectual development, intrinsic motivation, and class performance between female and male students. Thus, as hypothesized, female students demonstrating high intellectual development with more sophisticated beliefs that knowledge is personally construed, complex, and evolving had higher intrinsic motivation and class performance than female students with low intellectual development. In contrast and surprisingly, male students with low intellectual development, believing that the structure of knowledge is simple, absolute, and certain, had higher levels of intrinsic motivation and class performance. These results suggest that intellectual development is a factor in learning exercise physiology and achieving class success only for female students. However, and contrary to our hypothesis, male students with low intellectual development performed better than male students with high intellectual development. The findings suggest that sex influences intellectual development, which has an effect on intrinsic motivation for learning a specific topic.

The results support recent findings documenting a significant relationship between the epistemological beliefs of students and their motivation to learn (16, 36). Furthermore, we extended the recent findings by documenting a positive relationship between intellectual development, intrinsic motivation, and class performance for female students only. Intellectual development is formed by a variety of life experiences related to sex, schooling, parental education, characteristics of the home environment, and background (33, 35). Thus, the students’ intellectual development is shaped by experiences before college as well as during college. It seems likely that the association between intellectual development and intrinsic motivation may represent a causal relationship because the level of intellectual development was established before college (16, 33, 35, 36). This suggests that intellectual development may actually affect or influence students’ motivation to learn.

It is important to note that class performance was determined by conventional measures of science teaching (i.e., multiple-choice exams) and not by other performance benchmarks, such as the level of insights offered by students during in-class discussions or the quality of essays/reports prepared outside of class time. It is possible that nonconventional determinants of class performance could minimize or perhaps expand the differences found between male and female students.

We documented statistical differences between female and male students regarding the association of intellectual development with both intrinsic motivation and class performance. From these results, we can conclude that the observed effects actually reflect the characteristics of the population rather than just sampling error. This does not necessarily, however, imply importance or scientifically meaning. The importance involves bringing together several central observations, joined with theories on the evolution of learning and motivation in young men and women. The novelty of this pairing as well as the virtually opposite results reported by sex are this report’s strengths. However, it is also important to note that the regression analyses, while detecting statistically significant differences, have very large residual variances, as witnessed by the data scatter and $R^2$ values. Accordingly, additional factors are contributing to the relationship between intellectual development and class performance for male and female students. Potential factors include the students’ level of physical fitness and body composition (4, 8, 21) as well as psychosocial factors including stress, self-esteem, and motivation (11, 20, 22). Sociodemographic and lifestyle factors, including household income, parents’ level of education, sleep duration, and eating habits, are also likely contributing to the relationship between intellectual development and class performance for male and female students (1, 2, 12, 14, 38). Finally, the different career paths chosen by male and female students may also influence the relationship between intellectual development and intrinsic motivation (7, 19). These possibilities merit future investigation.

Teachers have opportunities to promote motivationally and educationally productive epistemological beliefs among their students (16, 33, 35, 36). Specifically, intellectual development may progress from naive to sophisticated levels and enhance intrinsic motivation when students have sufficient time to grapple with information that is authentic and relevant to life situations. It is also important that students have success, master the context, and enjoy the experience. This is most effective in a supportive environment that shows enthusiasm and empathy and promotes deeper engagement and collaboration among students and faculty members.

Students must also be taught that knowledge is contextual. That is, information must be tailored and applied to different situations. Furthermore, students must discover that learning requires effort and struggle. To accomplish these educational goals, a variety of strategies can be established that include traditional and modern approaches as well as the opportunity for online interactive activities. In addition, an established and accepted set of competencies must be embedded during class instruction on a regular basis if we are to prepare students with skills for the 21st century. These competencies, known as The Four Cs of 21st Century Learning (http://www.nea.org/assets/docs/A-Guide-to-Four-Cs.pdf), include critical thinking, communication (student-student/student-faculty member), collaboration (collaborate groups), and creativity. For example, faculty members can promote intellectual development by assigning collaborative learning groups during class time for discussion, higher order thinking, problem-solving tasks, and open-ended questions that do not have straightforward solutions. Moreover, the practice of establishing immediate feedback during class raises students’ intrinsic motivation and allows students to manage their own daily performance by increasing curiosity and self-assessment. This can be done by promoting the practice of quick, nongraded, informal assessments (such as exit-tickets) or using modern technology applications that assess content taught via a manual device. In
addition, helping students value effort and growth rather than fearing failure supports intellectual development and, as a result, intrinsic motivation.

Prescriptions for change. Female students appear to have more sophisticated beliefs about the nature of knowledge. Specifically, more female students than male students believe that knowledge is organized as highly intertwined concepts, is uncertain, and that individuals have the capability to improve their learning skills. In contrast, male students are more likely to have less sophisticated epistemological beliefs that knowledge is acquired rapidly, is composed of a series of isolated independent facts, is unconditional, and that individuals have a predetermined ability to learn. These beliefs affect their motivations to learn and class performance.

The importance of intellectual development becomes apparent when considering our complex, 21st century world. The challenges of the 21st century do not have a clear set of rules or a simple, absolute, and certain solution. In fact, the rules and solutions are often controversial and uncertain. To find solutions and be successful in this environment requires an ability to accept ambiguity and work with uncertainty. It requires a mature or sophisticated level of intellectual development where people assess problems and make decisions that are based on evidence and situational context. However, traditional methods of instruction often promote and reward single best answers, only one correct answer and simple solutions. With this simplistic approach, students seek a clear set of rules and simple, single solutions.

This unsophisticated, immature approach works well for simple tasks, when there is a straightforward, uncomplicated set of rules and a clear solution. It works by narrowing focus and concentrating the mind. However, for the real world, and the challenges of the 21st century, the solutions are not known and are not solved by marching forward in a straight line. In the real world, the solutions are on the periphery. Rather than looking straight ahead, the students should be looking around. Looking straight ahead narrows the focus and restricts the possibilities.

Accordingly, we, as teachers, should be aware of the taxonomy of intellectual development and apply this understanding to environments of higher learning, thus preparing students to deal with complex problems so that they are better equipped to deal with the major issues of our times. These issues all require individuals that can address uncertainty, complexity, and conflicting perspectives with solutions that are based on evidence and analysis (23).

Thus, the illiterate of the 21st century will not be those who cannot learn to read and write but those who cannot learn to accept ambiguity and work with uncertainty. Accordingly, our responsibilities as teachers are to help students acquire 21st century skills that accommodate a world where the rules are often uncertain and the solutions are controversial and ambiguous, to prepare students to deal with complex personal and professional decisions. Importantly, students using this approach will be better prepared to deal with the major issues of our times, such as climate change, reproduction rights, equal protection under the law, diversity, technological challenges, and changing economic and geopolitical systems (23). These and other complex issues all require individuals who can nonsensically factor in explaining differences in educational attainment and earnings. Soc Sci Res 37: 888–902, 2008.

REFERENCES


