Student Beliefs about Intelligence: Relationship to Learning

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Abstract - **This study examined the relationship between engineering students' beliefs about intelligence and their self-efficacy for learning course material, their perceived use of deep learning strategies such as collaboration and knowledge building behaviors, and their course grade. Our results showed that self-efficacy, perceived use of collaborative learning strategies, and adaptive personal beliefs about intelligence were predictive of students' use of knowledge building behaviors. Intelligence beliefs were not predictive of course grade. These results contribute to the body of knowledge demonstrating the utility of these motivational concepts for understanding post secondary engineering students' effort and achievement; our results also provide important direction for educators, demonstrating the need to support incremental views of intelligence among engineering students.**

Index Terms – Academic achievement, Collaborative learning strategies, Intelligence beliefs, Knowledge-building behaviors, Self-efficacy.

THEORETICAL FRAMEWORK

An understanding of students' beliefs about intelligence adds valuable information to the complex picture of factors that influence success in their coursework. In engineering education, increasing concerns about student retention have led researchers to pursue possible explanations for students' academic successes and failures. As we scrutinize students' learning behaviors in an effort to determine why those in challenging courses fail or drop out, it is important to look deeper than the actions we see in the classroom or infer from their test scores. Examination of students' beliefs about themselves, or self-theories, may provide important insight into their behavior.

Most students enter a classroom with one of two distinct conceptions of their intellectual ability. Some students feel that their intelligence is a fixed trait, or an entity that they possess, and that they can do nothing to change it; this is referred to as an *entity theory* of intelligence. Students who adopt an entity theory of intelligence usually believe that they either "have it" or they "don't have it." Other students feel that their intelligence is malleable, or can be incrementally increased through their own efforts to learn; this is referred to as an *incremental theory* of intelligence [1]. Although it was once believed that most individuals in our society held entity beliefs regarding intelligence, surveys of adults and children show mixed results: 40% of individuals typically indicate incremental beliefs, 40% indicate entity beliefs, and 20% are undecided [2]. Researchers have also found that people can hold different intelligence beliefs for different academic domains [3]. For example, a common area where students hold entity beliefs is in mathematics. Students may believe they have fixed math ability and that even with the most accomplished professors or mentors, they will never be able to learn sophisticated mathematical procedures; this reflects an entity belief. At the same time, they may believe that they can improve their vocabulary or reading comprehension by regularly reading the newspaper or complex literature, thus holding an incremental belief about their verbal ability.

The beliefs that students hold about their intelligence have been shown to produce distinct variations in their orientations to learning and their reactions to failure. Those who hold incremental beliefs exhibit an adaptive approach to learning. These students often seek to improve their ability by selecting challenging activities and exerting effort to learn [4,5]. They view exertion of effort as a positive behavior, a means to becoming more intelligent [2], and they dedicate that effort to use of deep learning strategies, such as organization and elaboration, to learn course material [6]. Deep learning strategies have been positively associated with academic achievement [7,8] and have also been associated with better long-term retention of course material in post-secondary students [9]. If students with incremental beliefs encounter difficulties or failure, their self-efficacy [10], or confidence in their ability to learn, is not shaken. Because they associate learning with effort, they tend to attribute their difficulties to their ineffective effort and vow to work harder [2].

On the other hand, students holding entity beliefs exhibit a less adaptive approach to learning. Because these students believe their intellectual ability is innate, they worry about having enough of it [4]. They often seek to confirm or prove their ability relative to others, choose easier tasks [5], and tend to exert less effort to learn. Exertion of effort is viewed as a negative behavior, as it is perceived as a sure sign of low intelligence, or inability [2]. Students who hold entity beliefs often use superficial learning strategies, such as rehearsal, to learn course material [11,12] instead of elaboration or critical thinking strategies [13]. Whereas superficial strategies may be effective for learning material to be recalled, it is well known that rehearsal strategies like memorization do not help with comprehension of complex concepts, such as those inherent in engineering knowledge. When students with entity beliefs encounter setbacks, they often attribute them to their lack of ability, telling themselves that they "just don't have it." Instead of devoting more effort to learn the material in these situations, students with entity beliefs tend to do just the opposite. In a study done at the junior high level, students reporting entity beliefs who had failed a test stated that they would spend less time on the subject in the future, would never take the subject again, or would cheat on the next exam [14]. These reactions serve to illustrate the complex response to failure that is often exhibited by students with entity beliefs. Unlike their peers with incremental beliefs who view failure as a sign to exert more effort, students with entity beliefs view their failure as a reflection of their low ability. They begin to doubt their capability for success and thus, their self-efficacy, or confidence to learn course material, begins to erode.

Examination of this relationship between student beliefs and their approach to learning is significant to engineering education because many students in the 'hard sciences' such as engineering report entity-type beliefs about their ability [15]. When faced with difficult courses and disappointing exam grades, Seymour and Hewitt [16] found that these students quickly begin to question their ability and their reasons for being in the engineering major. If entity beliefs are prevalent in this population, and are associated with lower exertion of effort, sub optimal learning strategies, or lowered confidence in the face of difficulty, this combination may not bode well for the academic success or retention of many engineering students. The current study will examine the relationship between intelligence beliefs held by a large sample of engineering students, their self-efficacy or confidence for learning course material, and their use of active learning strategies in their engineering coursework.

Intelligence beliefs have also been associated with academic achievement in post secondary students [17], and younger age groups [11,14,18]. In the study done by Blackwell and colleagues [14], intelligence beliefs of junior high students were examined in relation to their math grades throughout their junior high years. It was found that students who held incremental beliefs achieved progressively higher math grades each semester. Most notably, this increase in performance occurred in junior high, a time in students' educational trajectory when they are most likely to experience a general decrease in academic performance. Students with entity beliefs however, did not show the same improved performance over time in the same study. The students who reported entity beliefs exhibited a decrease in performance over the two-year period. Stipek and Gralinski [11] also found that entity beliefs and their associated superficial learning strategies were related to lower achievement in older elementary students. The work that has been done across all age groups shows fairly consistent results with regard to achievement, but no studies have examined this outcome specific to an engineering context. This study will extend previous work by examining the relationship between students' intelligence beliefs and achievement in a large sample of engineering students.

Another active learning strategy that has been shown to increase achievement in engineering students is collaboration [19-21]. Whether engaging in casual conversation after class or working together on an assigned group project, those who use collaborative learning strategies have opportunity to share ideas, challenge each others thinking, and ultimately learn from one another [22]. Research has shown that students who feel confident in their ability to learn course material and actively use knowledge-building strategies in their coursework also include collaboration in their repertoire of learning strategies [23]. Although collaboration was not named in the literature as a strategy resulting from implicit theories of intelligence, it is an active learning strategy utilized by many students; it reflects extra effort to learn course material, which is characteristic of those with incremental beliefs.

The influences of students' beliefs about their intelligence on their confidence for learning, learning strategies, and eventual academic successes make it important that we fully explore this motivation construct in the engineering student population. This study examined the relationship between engineering students' intelligence beliefs and their active learning strategies, confidence in their ability to learn course material, and achievement. Our research questions were 1) What type of intelligence beliefs are prevalent in the engineering student population? 2) What is the relationship between students' intelligence beliefs and their perceived use of knowledge building behaviors and collaborative learning strategies in their coursework? 3) What is the relationship between students' intelligence beliefs and their perceived self-efficacy or confidence for learning course material? 4) What is the relationship of students' intelligence beliefs and their course grade? Based on our review of the literature, we expected that entity beliefs may be predominant in engineering students, and that these beliefs would be associated with their confidence for learning course material, use of knowledge building behaviors, and use of collaboration as a learning strategy. Accordingly, we also expected that students' intelligence beliefs would also be predictive of their grade in their required engineering courses.

METHOD

I. Participants

The study participants were 437 engineering students recruited from 11 different required mechanical and aerospace engineering (MAE) and electrical engineering (EEE) courses at a large public university in the southwestern United States. Approximately 17% of the sample was female, and the age of participants ranged from 16 to 45 years. Of the courses where students were surveyed, 15.6% were at the 100 level, 51% were at the 200 level, and 33.4% were at the 300 level. The reported ethnicity of the participants was 63% Caucasian, 15% Latino, 11% Asian, and less than 1% African American.

II. Measures

- **Implicit Theories of Intelligence Scale** (ITIS): The ITIS scale [4] is an established measure of self-theories about ability. This six-item scale assessed students' beliefs about the stability or malleability of intelligence. Example items from the scale are "No matter how much intelligence you have, you can always change it quite a bit," and "Your intelligence is something about you that you can't change very much." The students responded on a Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).
- **Student Perceptions of Classroom Knowledge-building** (SPOCK): The SPOCK subscales [24] are established measures of student study strategies that have been tested and shown to be reliable measures within the engineering student population [23]. We utilized two SPOCK subscales to assess students' perceptions: The eight-item *knowledge-building* subscale assessed students' tendencies to construct their own understanding of classroom material. Examples of knowledge-building items are "Whenever I learn something new in this class, I try to tie it to other facts and ideas that I already know," and "I try to go beyond what we are given in the lectures and text." The five-item *collaborative learning* subscale assessed student interaction with their classmates. Example items from this subscale are, "In this class, my classmates and I actively share ideas," and "In this class, my classmates and I actively work together to learn new things." The students responded on a Likert-type scale ranging from 1 (*almost never*) to 5 (*almost always*). The SPOCK subscales did not assess the professors' instructional strategies but rather student perceptions about learning classroom material. The subscale items were classroom-specific, and participants were asked to focus on only one class when completing the items.
- **Motivated Strategies for Learning Questionnaire** (MSLQ): The MSLQ [25] is an established scale utilized to evaluate students' motivation behaviors and their use of different study strategies. Only the eight-item subscale related to self-efficacy for learning course material was administered to participants of this study. An example item from this subscale was, "I am confident I can understand the basic concepts taught in this course." The students responded on a Likert-type scale ranging from 1 (*not at all true of me*) to 7 (*very true of me*).
- **Course Grade**: Students' course grades were retrieved from the university registrar's office and included in the data set as measured on a 4 point plus or minus grading system. The highest possible grade was an A+ (4.33) and the lowest possible grade was no credit (0.00).

III. Procedure

Data for the current study were obtained in the spring and fall of 2008 via online survey. Students were informed about the survey by an announcement placed on their course website or by an email sent to them by their course faculty. Students could take the survey at their convenience and they received a monetary incentive of ten dollars for their participation. Course grades were obtained from the university registrar.

ANALYSIS

Scale scores were obtained for each student by calculating a mean score from the respective items contained in each of the four scales used in the survey. Descriptive statistics were completed on the data and examined. Pearson product-moment correlation coefficients [26] were then completed among the study variables. To eliminate differences in reported scores that may have resulted from instructor influence, scale scores for the variables of interest were converted to z-scores by course to preserve within group position but remove between course differences. A dependent samples t – test [27] was done to examine for differences in students' incremental and entity beliefs. Multiple regression analysis [26] was then done to examine the predictive ability of intelligence beliefs, self-efficacy, and collaboration on knowledge building behaviors. Multiple regression analysis was repeated to examine the predictive ability of the variables on students' course grade.

RESULTS

Descriptive statistics showed that the data met assumptions required for the intended analysis (See Table I).

TABLE I
DESCRIPTIVE STATISTICS FOR ALL VARIABLES (z-SCORES)

	Min	Max	*M*	*SD*	Skew
ITIS-INCRE	-2.99	1.83	-0.02	0.98	-0.35
ITIS-ENT	-1.99	3.21	0.03	1.00	0.48
SPOCK-KB	-3.28	2.39	0.01	0.99	-0.41
SPOCK-CL	-2.54	2.19	-0.03	1.00	-0.22
MSLQ	-3.59	1.96	0.01	0.99	-0.63
Course Grade	-2.31	1.32	0.00	1.00	-1.01

Note: Listwise N = 432. ITIS-INCRE = Incremental beliefs; ITIS-ENT = Entity beliefs; SPOCK-KB = Knowledge building; SPOCK-CL = Collaborative learning strategies; MSLQ = Self-efficacy.

Analysis revealed a positive correlation between students' incremental beliefs and reported collaborative strategies (r = .12) and knowledge building activities (r = .20). Conversely, entity beliefs were negatively related to students' reported knowledge building behaviors, (r = -.15), and neither of the two intelligence beliefs was significantly related to students' confidence in their ability to learn course material (See Table II). The dependent samples t-test showed that engineering students' incremental beliefs were significantly

TABLE II

CORRELATIONS AMONG STUDY VARIABLES

	1.	2.	3.	4.	5.
1. ITIS-INCRE	-				
2. ITIS-ENT	**-0.76****	-			
3. SPOCK-KB	**0.20****	**-0.15****	-		
4. SPOCK-CL	**0.12***	-0.08	**0.36****	-	
5. MSLQ	-0.01	-0.07	**0.32****	**0.15****	-
6. Course Grade	-0.02	-0.03	**0.17****	**0.19****	**0.43****

Note: ** $p < .01$; * $p < .05$. Listwise N = 432. ITIS-INCRE = Incremental Beliefs; ITIS-ENT = Entity beliefs; SPOCK-KB = Knowledge building; SPOCK-CL = Collaborative learning strategies; MSLQ = Self-efficacy.

greater than their entity beliefs, t (433) = 9.36, $p < .01$. Results of the first multiple regression analysis showed that students' self-efficacy, perceived collaborative strategies, incremental beliefs, and entity beliefs were predictive of their knowledge building behaviors, $F(4,427) = 31.83$, $p < .01$, adj. $R^2 = .22$. After eliminating the nonsignificant predictor, entity beliefs, the model was re-evaluated. The second model including self-efficacy, perceived collaborative learning strategies, and incremental beliefs accounted for 22% of the variance in students' knowledge building behaviors, $F(3,429) = 42.58$, $p < .01$, adj. $R^2 = .22$, with incremental beliefs accounting for 3% of the total variance (See Table III). A third multiple regression analysis using course grade as the dependent variable showed that only students' self-efficacy and perceived collaborative strategies were significant predictors; students' intelligence beliefs did not significantly predict their course grade.

TABLE III

MULTIPLE REGRESSION RESULTS

Model / Variables	Model R^2	$R^2_{adj.}$	*B*	*SEB*	β	sr^2
Knowledge Building						
Model 1	.23**	.22				
Intercept			.02	.04		
MSLQ			.29**	.04	.28	.08
SPOCK-CL			.29**	.04	.29	.08
ITIS-INCRE			.20**	.07	.20	.02
ITIS-ENT			.04	.07	.04	-
Model 2	.23**	.22				
Intercept			.02	.04		
MSLQ			.29**	.04	.28	.08
SPOCK-CL			.29**	.04	.30	.08
ITIS-INCRE			.17**	.04	.17	.03
Course Grade						
Model 1	.20**	.19				
Intercept			-	.04		
MSLQ			.42**	.05	.41	.15
SPOCK-KB			-.01	.05	-.01	-
SPOCK-CL			.13**	.05	.13	.02
ITIS-INCRE			-.08	.07	-.08	-
ITIS-ENT			-.06	.07	-.06	-

Note: ** $p < .01$; * $p < .05$. Listwise N = 432. MSLQ = Self-efficacy; SPOCK-KB = Knowledge building; SPOCK-CL = Collaborative learning strategies; ITIS-INCRE = Incremental beliefs; ITIS-ENT = Entity beliefs.

DISCUSSION

Our study provided interesting results with regard to the prevalence of incremental beliefs in engineering students. Although it is believed that a predominant number of those in disciplines such as engineering possess entity beliefs [15], we did not find that to be the case. In our sample, engineering students' incremental beliefs were significantly higher than their entity beliefs. Our results also showed that engineering students who believe intelligence is malleable are more likely to engage in active learning in the form of collaborative learning strategies and knowledge building behaviors; in our sample, these active learning strategies were significantly positively associated with students' course grade. In contrast, engineering students who reported entity beliefs were significantly less likely to engage in knowledge building behaviors. Findings such as these should stimulate thought among engineering educators about how these beliefs develop and how they might cultivate them in their students.

Although researchers believe that early intelligence beliefs are fostered by parental behaviors [4], teachers and others encountered as students mature also influence these beliefs [16]. High school teachers and counselors are frequently the ones who encourage students to pursue engineering; in doing so, they often unknowingly perpetuate entity beliefs by referring to students' math and science ability as a "talent" they possess rather than emphasizing students' ability to learn as the positive attribute. When making the choice to become an engineer, many students report being told that they were "good at math and science" and that this ability would make them good candidates for the profession [16]. These types of statements support the "have it" or "don't have it" view of ability. If students later encounter difficulties or failure along their educational path, they may be left without confidence in their ability to succeed because they may feel that for some reason, they just don't "have it" any longer. Despite our finding that *some* students had higher incremental beliefs, there are still students who hold entity beliefs that may be vulnerable to this sequence of events.

Although it might seem too late at the post secondary level to undo perceptions that students have been developing since early childhood, studies have shown that small interventions do indeed make a difference. In one study by Aronson and his colleagues [17], African American and Caucasian college students were taught about either the incremental theory of intelligence, the theory of multiple intelligences [28], or received no instruction about the topic. The multiple intelligence theory gave the message that individuals either had ability or lacked ability in different areas of intelligence and thus served as illustration of the entity theory. As part of the study methodology [17], students were assigned to be mentors to fictional middle school students who were characterized as being at high risk academically; the study participants were required to write letters of encouragement to their middle school "pen pals," to convince them that success was possible despite the middle school students' current situation. The college students were encouraged to tell stories from their own life that illustrated the strength of their arguments about intelligence. The real intent of the letter writing activity was to persuade the study participants (college students who had been taught about the incremental theory) that intelligence could indeed be improved incrementally [17]. The college students were also required to turn the letters to their middle school "pen pals" into speeches, believing that the speeches would be used in the future to counsel at-risk students. The speeches were audiotaped, and participants listened to their own speeches. At the end of the semester, the college students who had been taught incremental theory and in turn, had persuaded their "pen pals" of its importance earned higher grades than their counterparts who learned about multiple intelligences. The incremental group also showed a greater valuing of academics and reported greater enjoyment of their coursework. Additionally, African Americans in the incremental group reported exposure to low ability stereotypes in their academic environment, as did the African American students in the other groups. However, despite the negative stereotype that African American students were labeled with, those with incremental beliefs felt capable of improvement, lessening the effect of the stereotype. This study points out the value of not only learning about incremental views of intelligence, but of developing ways to inspire students to advocate them. Those who advocated the incremental theory of intelligence to others integrated it into their own thinking and retained their views over time.

Our study results did not show a positive relationship between intelligence beliefs and students' course grades. As previous studies have shown [14,17], the effect of intelligence beliefs on performance may be evident if these variables were evaluated over time, and there may be other motivational factors that mediate this relationship. However, the positive association between students' self-theories and their active learning strategies still provides important direction for course instructors with regard to nurturing students' adaptive beliefs about learning in the classroom.

Our results give credence to the faculty practice of encouraging incremental beliefs in students. Praise and feedback have been associated with the development of either entity or incremental beliefs [29]. Praise or feedback that emphasizes students' intellectual ability, e.g., "you're a genius," promotes the idea that ability is innate, and supports students' entity beliefs, whereas communication that acknowledges their effort is much more likely to nurture the idea that they have continued ability to learn, or incremental beliefs.

It is also important to emphasize to students that course material is within their grasp, and that learning will occur if they expend the effort to do so. Schommer [30] recommends explicitly telling students that higher-level learning is challenging and requires intense effort in order to succeed; the ensuing struggle to learn the material is bound to produce emotions, and facing a difficult task should be viewed as a challenge, rather than a potential failure. She adds that students should be encouraged to work harder and attempt multiple strategies to meet their goal. Schommer recommends assignment of complex problems that have no clear-cut answer to provide opportunity for this type of experience. Faculty support that includes identification of acceptable answers as students tackle these types of challenges will foster the idea that effort can result in success, a core assertion of incremental beliefs.

Another approach might be to share with students some of the findings from neuroscience research about the brain's continued capacity for learning throughout the lifespan [31,32,33]. During that conversation, faculty could discuss how particular assignments and coursework serve to provide opportunities for continued learning.

Lastly, reminding students frequently that intelligence is malleable can serve to reinforce this vital belief. Although seemingly simple, these interventions may provide significant returns with regard to the way students approach learning in the classroom.

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