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ABSTRACT

Students begin their college studies with a set of epistemological beliefs about what they think knowledge is and how they think it is learned; for most students, the experience of college alters these beliefs in fundamental, transformative ways. This study explores the relation between epistemological beliefs, motivation, and cognition in two differing instructional contexts within the same mathematics course. The subjects included 438 first-semester calculus students at a large Midwestern research university. Students were enrolled in either experimental (New Wave) calculus sections or traditional calculus sections. Results indicated that intrinsic motivation and self-efficacy were correlated with sophistication of beliefs, though this was not true within the New Wave sections. This result suggests that students with more sophisticated beliefs, as measured by a strategies for learning questionnaire, are those students who reported that they are mastery-oriented and think that they are capable of doing well in mathematics. Intrinsically motivated students reported relative disagreement with the view of math as an isolated activity; the findings could be used to argue for the importance of group activities within mathematics. The results also provide some evidence for correlations between epistemological beliefs about mathematics and type of instruction. (RJM)

Epistemological Beliefs and First-Year College Students: Motivation and Cognition in Different Instructional Contexts

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Abstract

Students begin their college studies with a set of epistemological beliefs about what they think knowledge is and how they think it is learned; for most students, the experience of college alters these beliefs in fundamental, transformative ways. There is evidence that beliefs may affect academic performance and comprehension, and that there are connections between epistemological beliefs, motivation, and student learning. Less is known about how different instructional environments interact with epistemological beliefs. This study looks at relations between student beliefs about knowledge and motivation within two instructional contexts in introductory calculus, each with different epistemological assumptions. Sophistication of epistemological beliefs was found to be correlated with intrinsic motivation, self-efficacy, and self-regulation, as well as with course grades; at the end of the term, students enrolled in the more active, collaborative sections exhibited more sophisticated beliefs than students in traditional lecture sections.

Epistemological Beliefs and First-Year College Students: Motivation and Cognition in Different Instructional Contexts

Students begin their college studies with a set of epistemological beliefs about what they think knowledge is and how they think it is learned; for most students, the experience of college alters these beliefs in fundamental, transformative ways (Baxter Magolda, 1992; Perry, 1970, 1981). There is some evidence that beliefs about knowledge may affect academic performance (Schommer, 1990, 1992) and comprehension (Schommer, 1990; Schommer, Crouse, & Rhodes, 1992). Recent work shows that there are positive connections between epistemological beliefs, motivation, and student learning (Schutz, Pintrich, & Young, 1993). Epistemological beliefs were correlated with both mastery goals and student engagement of course material. Little information is available, however, regarding such connections within different disciplinary domains or how differing instructional environments influence such beliefs. This current study is an attempt to explore the relation between epistemological beliefs, motivation, and cognition in two differing instructional contexts within the same mathematics course, each with different epistemological assumptions.

Epistemological beliefs

A number of schemes have been derived to represent beliefs about knowledge (Baxter Magolda, 1992; Belenky, 1986; King & Kitchener, 1981; Kitchener & King, 1994; Kuhn, 1991; Perry, 1970; Schommer, 1990, 1992).

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These schemes have proposed a number of different dimensions regarding epistemological beliefs, but there are some commonalities across the schemes. Although further work is need to delineate the dimensions of epistemological beliefs, critical dimensions seem to include: the nature of knowledge, simplicity or complexity of knowledge, the source of knowledge, the certainty of knowledge, the stability of knowledge, how knowledge is validated, and how the individual comes to know. Among those taking a developmental view (Kitchener & King, 1981; Kuhn, 1991; Perry, 1970), individuals are generally perceived as beginning with absolutist notions of knowledge passively received and moving toward positions in which ideas are more complex and less certain, and meaning is actively constructed. Throughout the literature there is a shared presumption that these beliefs affect one's educational experience, but the process by which this happens is seldom specified.

Much of the work on epistemological beliefs of students has appeared to presume a common mode of beliefs across disciplinary domains. Students may in fact hold beliefs that differ by subject area, developed and strengthened through classroom experience. Beliefs particular to mathematics have been defined (Schoenfeld, 1992) but have received little empirical validation. Schoenfeld (1992) claims that beliefs about mathematics shape behavior in ways that have powerful, and often negative, consequences. For example, one naive belief about mathematics is that those who really understand math should be able to work any assigned problem quickly. Individuals who hold this belief may refrain from persevering on a problem more than a few minutes, although continued effort may have lead to success.

Relation between epistemological beliefs and motivation and cognition

Beliefs about knowledge may affect one's perception of the educational process and the type of work necessary to accomplish tasks; in other words, beliefs may shape academic behavior. Several correlational studies point to epistemological beliefs as predictors of student academic work (Schommer, 1990, 1992). Belief in quick learning (belief that learning happens in a short amount of time or not at all) predicted oversimplified conclusions, poor performance, and over confidence; belief in "certain knowledge" (belief that knowledge is certain and unchanging) predicted inappropriately absolute conclusions on an essay completion task (Schommer, 1990). In another study, high school grade point average was positively correlated with sophisticated beliefs across four dimensions: quick learning, simple knowledge, certain knowledge and fixed ability (Schommer, 1993). Overall, students with more sophisticated epistemological beliefs were likely to exhibit higher academic performance. These studies are limited to one model of epistemological beliefs, however, and one which does not contain elements central to other schemes, such as source of knowledge or knowledge validation.

Epistemological beliefs may also be related to motivation and cognition In another correlational study, Schutz, et al. (1993) found that students who adopt a more sophisticated perspective toward knowledge were more likely to adopt a mastery goal to learning and to engage material more deeply. Students' motivational orientation has been linked to cognitive engagement and self-regulation in the classroom, and both self-efficacy and intrinsic value have been correlated with use of cognitive strategies, self-regulated learning, and persistence (Pintrich & De Groot, 1990). Epistemological beliefs may also play a mediating role in this process, as beliefs about knowledge may affect selection of study strategies, which then affect engagement and performance.

Path analysis conducted in a study of students' comprehension of a statistical passage indicated that the less students believed in simple knowledge (the belief that knowledge is composed of isolated facts), the more meaningful study strategies they used, and the better they performed on a test (Schommer, 1992). None of these studies, however, examine domain specific beliefs or the effect of instructional context.

The instructional environment

Considerable speculation exists about how instructional environments interact with epistemological beliefs, but little empirical work has been done in this area. Although there is evidence of considerable variation in knowledge beliefs among college seniors (Baxter Magolda, 1992; Perry, 1970), little work has been done to explain how instructional experiences might explain this variation. Similarly, although students in different types of postsecondary institutions (junior college versus university) exhibit differences in epistemological beliefs (Schommer, 1993a), no examination of the instructional practices which might partially explain this have been undertaken.

Researchers ranging from Perry (1970) to Schommer (1990) have reached similar conclusions: that we need to know more about the instructional environment that supports students in the development and application of more sophisticated reasoning and beliefs about knowledge. Prescriptions for addressing the issue in the classroom have included the recommendation of Schommer (1990) that "teachers can inform children in grade school that knowledge is integrated, that prior knowledge should be accessed, and that many times there is more than one right answer." (p. 503-504) The idea that simply informing students of this particular view will produce belief change seems to contradict evidence of the possible developmental progression of epistemological beliefs (Baxter Magolda, 1992; Perry, 1970; Schommer, 1992). Furthermore, teacher pronouncements may have little effect in the reconstruction of beliefs, as it may be the student's actual experience of the classroom that shapes beliefs. Teacher rhetoric is often contradicted by classroom structure, as well as by the reward system (Schoenfeld, 1988). Thus, changing student beliefs may require changing the meaning of knowing and learning in school (Lampert, 1990).

Recommendations for classroom conditions to enhance development across epistemological positions include encouraging student questions and comments, instructor recognition of student reactions, and increased emphasis on student participation (Baxter Magolda, 1987). Such development may also be furthered by curricular approaches that validate the student as knower, situate learning within the students' experience, and create opportunities for students to construct meaning with others. (Baxter Magolda, 1992).

The current study builds on existing foundations and looks at the relation between student beliefs about knowledge and motivation within two instructional contexts in introductory calculus at a large research university, each of the contexts with different pedagogical and epistemological assumptions. During the time of the study, ten of the sections were taught through experimental methods, an approach being called "New Wave" calculus. These sections emphasized active learning, collaborative learning in and out of class, the use of graphing calculators, and a curriculum based on a new text, largely a collection of complex word problems for which answers are not provided. The remaining sections were taught in more traditional methods, with a standard calculus text that proceeds sequentially; instructors were expected to cover a set amount of material primarily through lecturing and demonstration of problem sets. The "New Wave" approach offers a relatively more sophisticated epistemological approach to the learning of calculus, in that students are expected to collaboratively construct mathematical knowledge and rely less on the instructor as the source of knowledge, and to work situated problems with potentially multiple approaches and more complex solutions.

Given these two types of classrooms, the research questions included:

1) What is the relation between epistemological beliefs, student motivation, and strategy use? It was predicted that students with more sophisticated beliefs would be more intrinsically motivated, more self-efficacious, more self-regulating and make greater use of elaboration strategies.

2) What is the relation between epistemological beliefs and academic achievement? It was predicted that students with more sophisticated beliefs would demonstrate higher academic achievement.

3) What is the relation between classroom context and epistemological beliefs? It was hypothesized that students in classes that focus on instructional methods emphasizing active learning, complex problem solving tasks, and collaborative learning, would be more likely to exhibit more sophisticated beliefs than those in sections receiving traditional instruction, which is primarily lecture based.

Method

Subjects

The participants in this study were 438 students enrolled in first-semester calculus at a large midwestern research university. Of these, 46.1%

were female (n=202), 12.1% were African-American or Hispanic (n=53), and 91.8% were first-year students (n=402). Students were enrolled in either experimental (New Wave) calculus sections or traditional calculus sections; of those in the sample, 19.6% were in New Wave calculus (n=87). Students registered for the calculus course without knowing the type of instruction that would be utilized in each section.

Measures

The questionnaire contained selected items from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, and McKeachie, 1993), along with an introductory section of demographic questions including proposed major, previous calculus study, plans for continuing calculus study, and advanced placement test reporting. The questionnaire included seven items relating to epistemological beliefs about mathematics. Questionnaires were distributed by the course instructors during the final week of class and students were asked to complete them at home and return them to the instructor before the end of the term.

Motivation and learning strategies

Motivational and learning strategy items were adapted from the MSLQ (Pintrich, et al., 1993) a self-report instrument designed to assess college students' motivational orientations and their use of different learning strategies for a college course. Students rate themselves on a seven-point Likert scale from "not at all true of me" to "very true of me." Items were selected for relevance to this course and were modified, where necessary, to contain references to math. Reported alphas are from scale construction within this study.

Items utilized are those in four areas: intrinsic goal orientation, self-efficacy, self regulation and elaboration. Among the three motivational scales, intrinsic goal orientation (α=.66) consisted of three items concerning the degree to which students participate in a task in math class for reasons such as mastery or curiosity. (Sample questions: "I prefer course material that is new and challenging to material I have previously studied." "The most satisfying thing for me in this course is trying to understand the context as thoroughly as possible.") Self-efficacy (α=.88) consists of four items involving judgments about one's ability to accomplish a math task as well as confidence in the ability to perform that task. (Sample questions: "I'm confident I can learn the basic concepts taught in this course." "Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.")

Learning strategy items are reflected in two scales. The self-regulation strategies scale (α=.59) consists of seven items that refer to metacognitive processes of planning, monitoring and regulating one's cognitive activities. (Sample questions: "When studying math, I try to determine which concepts I don't understand well." "I ask myself questions to make sure I understand the material I have been studying in a math class.") The elaboration strategies scale (α=.62) is based on four items related to strategies that help students build internal connections between items to be learned. (Sample questions: "When studying math, I try to relate the material to what I already know." "When I study math, I pull together information from different sources, such as lectures, readings and discussions.") On all four of these MSLQ scales, a higher score indicates greater agreement, and therefore higher motivation or strategy use.

Epistemological beliefs

Six items chosen to tap students' epistemological beliefs were adapted from a list of typical student beliefs about the nature of mathematics (Lampert, 1990; Schoenfeld, 1992). These reflect the degree to which students hold simplistic beliefs about mathematical knowledge, such as the importance of being able to get a right answer quickly, or that mathematics learned in school has little value or application. Factor analysis was conducted using the mean scores of the six items. With orthogonal varimax rotation and an eigenvalue greater than 1.0 as a cutoff point, two factors were generated, accounting for 44.3% of the variance. The resulting scales consist of three items each, a simple beliefs scale (α=.48): (e.g., "Mathematics problems have one and only one right answer") and an isolated beliefs scale (α=.41) (e.g., "Math is a solitary activity done by individuals in isolation.") In addition, given the low alphas for the two separate scales, all six items were combined into a math beliefs scale (α=.54). Agreement with these items indicates an acceptance of typical, relatively unsophisticated views about the nature of mathematics. Thus the lower the mean score for the scale or subscale, the more sophisticated the beliefs.

Achievement measures

Achievement measures include: 1) final grades in the course, and; 2) scores on ten items which appeared on the final examination used in all sections of the course. These ten items were calculus problems that instructors from both types of sections could agree were representative of the coursework across sections. Grades were reported on a scale of 0 - 4.3; scores on the ten common final items are reported on a scale of 0 - 10.

Results

Response rate on the questionnaire was 25.2%. Of the 1738 students enrolled in the course, 438 returned the questionnaire. Preliminary analysis of respondents and non-respondents indicated no significant differences in ethnicity or year of study. There were, however, proportionately more women than men among the respondents; 46.2% of the respondents were female, compared to 40.7% of those enrolled in the course ($p < .01$). In regard to previous academic performance, respondents had a statistically significant higher grade point average in high school, a mean of 3.67 compared to an overall mean of 3.61 ($p < .001$), although this is not a particularly meaningful difference academically. There were no differences between respondents and non-respondents on math and verbal scores of either the SAT or the ACT. Proportionately more students in the New Wave sections completed the questionnaire than those in the traditional sections ($p < .001$); 19.9% of the respondents are in New Wave classes compared to 17.3% of those sampled.

In the absence of a pre-questionnaire on epistemological beliefs, further analyses were performed to look at whether differences existed among respondents between the traditional sections and the New Wave sections on basic demographic and prior achievement variables. There were no statistically significant differences by gender or ethnic group. Nor were there significant differences in previous high school calculus background, high school grade point average, SAT math scores, or ACT math scores.

The initial set of hypotheses regarded correlations between beliefs and motivation and between beliefs and learning strategies. Listwise deletion of missing data resulted in a total sample of 428. The motivational scales were <u>intrinsic motivation</u> and <u>self-efficacy</u>; learning strategy scales were <u>self-regulation</u> and <u>elaboration</u>. Descriptive statistics appear in Table 1. In the overall sample, intrinsic motivation was correlated with sophistication of math beliefs (r=-.17, p=.001). (See Table 2.) The correlation was similar in the traditional sections (r=-.19, p=.001) and New Wave sections (r=-.14, p=.10). The simple beliefs scale was not significantly correlated with intrinsic motivation, but the isolated beliefs scale was significantly correlated with intrinsic motivation for the overall group (r=-.24, p=.001), for those enrolled in traditional sections (r=-.23, p=.001), and for those in New Wave sections (r=-.25, p=.01). Thus the less likely students were to see math as an isolated activity, the more likely they were to report being intrinsically motivated.

Self-efficacy followed a similar pattern, correlating significantly with sophistication of math beliefs in the overall sample (r=-.13, p=.001) and in traditional sections (r=-.14, p=.001), but not in New Wave sections (r=-.12, p=.14), although there was little actual difference. The simple beliefs scale was not significantly correlated with self-efficacy. Self-efficacy was correlated with a more sophisticated view of math on the isolated beliefs scale for the overall sample (r=-.19, p=.001), the traditional group (r=-.21, p=.002) and the New Wave group (r=-.16, p=.07).

Self-regulation also was correlated with sophistication of beliefs. In both the overall group and the traditional group, there was a significant correlation (r=-.16, p=.001 for total; r=-.22, p=.004 for traditional), though not in the New Wave sections. On the simple beliefs scale there was a correlation between sophistication of beliefs and self-regulation for the traditional group (r=-.13, p=.01). On the isolated beliefs scale, results were significant for all three groups. More sophisticated beliefs were correlated with self-regulation for the overall group (r=-.21, p=.001), the traditional group (r=-.22, p=.001) and the New Wave group (r=-.21, p=.03).

Use of elaboration strategies was not significantly correlated with overall math beliefs for any of the three groups, nor was elaboration correlated with the isolated beliefs scale. However, on the simple beliefs scale, there was a correlation for both the total group (r=.08, p=.05) and the New Wave group (r=.19, p=.04) between elaboration and less sophisticated beliefs, not the direction that had been predicted. The correlation was not significant for the traditional group.

The second hypothesis was that students with more sophisticated beliefs would demonstrate higher academic performance. Descriptive statistics appear in Table 1. There were significant correlations between course grade and math beliefs, and in course grade and isolated beliefs, for both the total group (r=-.09, p=.04 for math beliefs; r=-.08, p=.05 for isolated beliefs) and the traditional group (r=-.10, p=.04 for math beliefs; r=-.09, p=.04 for isolated beliefs), all in the predicted direction. (See Table 2.) Higher course grades correlated with sophisticated beliefs. Overall differences in course grades between students in the New Wave and traditional classes exist, however, with those in the New Wave averaging a significantly higher course grade (t=-3.90, p=.001). No significant correlations existed between beliefs and performance on the ten items that were common to the final exams of both types of courses.

The third hypothesis was that students who were enrolled in classes with the instructional emphasis on active learning, complex problem solving tasks, and collaborative learning would exhibit more sophisticated beliefs than those enrolled in traditional classes. T-tests were performed to compare the means of the two instructional groups on the three beliefs scales . The difference in the mean for the two groups on the math beliefs scale was significant (t=1.96, p=.05), with students in the New Wave sections (M=2.02) exhibiting more sophisticated beliefs than those in the traditional sections (M=2.24). An examination of differences in the other simple beliefs scale also indicates a significant difference (t=2.01, p=.05), with those in the New Wave sections less likely to subscribe to the simple beliefs. Response to the items that form the isolated beliefs scale showed no significant differences.

Additional analyses were conducted to look at the possible relation between beliefs and instructional context. It seemed plausible that students with more sophisticated beliefs might demonstrate higher academic achievement in the New Wave sections and those with less sophisticated beliefs might perform better in traditional sections. Similarly, such matches of beliefs and instructional context might be likely to enhance motivation. An analysis of variance showed no interaction effects.

Discussion

As hypothesized, intrinsic motivation and self-efficacy were correlated with sophistication of beliefs, though this was not true within the New Wave sections. This may have been a problem of the small sample size in the New Wave sections; further exploration during future terms as the program expands will make it possible to reassess these correlations. What it does suggest is that students with more sophisticated beliefs, as measured by this instrument, are those who also report that they are mastery-oriented and think they are capable of doing well in mathematics. Furthermore, intrinsically motivated students also reported relative disagreement with the view of math as an isolated activity. The limits of a correlational study make it impossible to infer cause and effect in this situation, but the findings could be used to argue for the importance of group activities within mathematics.

Students with more sophisticated beliefs were also more likely to be self-regulating, but less likely to use elaboration strategies. The actual items chosen to measure use of elaboration strategies are probably more applicable to social science and humanities courses. Work may be necessary on identifying the more domain-specific learning strategies appropriate for mathematics. Correlations between grades and sophistication of beliefs give further impetus for understanding how students translate beliefs into performance and what the intervening strategy use might be.

The results provide some evidence for correlations between epistemological beliefs about mathematics and type of instruction. These should be interpreted with caution, however, as there was no assessment of beliefs prior to enrollment and assignment to sections was not random. The study showed that students enrolled in classes that emphasized active learning, cooperative group work, problem solving, and the use of graphing calculators were more likely than those in traditional classes to have more sophisticated beliefs about mathematics. If, as has been previously suggested (Schommer, 1992; Schoenfeld, 1988, 1992), beliefs often have debilitating effects on students, then the design of classrooms that challenge these beliefs is critical. Continuing exploration of this and similar instructional models may prove useful to the design of classes that foster more sophisticated beliefs.

There are several limitations to the findings. The response rate was considerably lower than expected, and there may be bias in the sample, with students of higher achievement responding disproportionately. In upcoming replications of the study more effort will be made to gain higher levels of cooperation from the instructors and the students. The measures were collected through a self-report instrument and need to be replicated in other ways, such as student interviews. Teacher interviews might provide evidence for linkage between teacher beliefs and student beliefs (Schoenfeld, 1992; Lyons, 1990) Most importantly, classroom observations are needed to begin to understand what particular aspects of the instructional context effect beliefs. More work is needed to address both the situated nature of beliefs and the manner in which beliefs are socially constructed.

A major weakness of the study is the untested nature of the six items that composed the math beliefs scales and the isolated and simple beliefs scales. Considerable item refinement and retesting needs to be done to affect reliability. The relatively low Cronbach's alpha coefficient (.51 for the math beliefs scale) suggests that there may be problems with internal consistency of the items. In addition, all items were not validated in any way except through face validity. The construct of epistemological beliefs both generally and within the domain of mathematics is quite vague and needs further attention.

The measures of cognitive performance in this study were course grades and scores on the ten problems common to the final exams given in all sections of the course. These were particularly problematic measures in identifying effects of instructional mode. Grades were not assigned in the same manner in the two types of courses, and the ten final items were simply paper and pencil measures. Further research might include the use of think-aloud protocols.

One problematic area of the study design is that instructors were invited to teach the New Wave sections of the course; all had previous, successful experience in teaching calculus through the traditional means. Traditional sections were staffed by both experienced teachers and novices.

These differences may threaten validity of those aspects of the study that compare differences in type of instruction.

We need to know more about how beliefs develop and if there are predictable progressions, and if they are domain specific. The evolution of epistemological beliefs through the apprenticeship of graduate training and into the early years of teaching could provide an important addition to the literature. We also need further investigation, within projects such as this one, into the distinctions between the learning curriculum and the teaching curriculum (Lave & Wenger, 1991).

Epistemological beliefs may play a powerful, but generally unarticulated, role in the classroom and in student learning. More multiple method studies are needed to understand the role instructional context plays in this process and how instruction can be designed to build on this growing body of knowledge.

Bibliography

Baxter Magolda, M.B. (1987). The affective dimension of learning: Faculty-student relationships that enhance intellectual development. College Student Journal, 21 (1), 46-58.

Baxter Magolda, M.B. (1992). Knowing and reasoning in college: Gender-related patterns in students' intellectual development. San Francisco: Jossey Bass.

Belenky, M.F., Clinchy, B. McV., Goldberger, N.R., Tarule, J.M. (1986). Women's Ways of Knowing: The Development of Self, Voice and Mind. New York: Basic Books.

Frazier-Kouassi, S., Malanchuk, O., Shure, P., Burkam, D., Gurin, P., Hollenshead, C., Lewis, D., Soeliner-Younce, P., Neal, H., & Davis, C.-S. (1992). Women in Mathematics and Physics: Inhibitors and Enhancers. Ann Arbor, MI: The University of Michigan.

King, P.M. & Kitchener, K.S. (1994). Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults. San Francisco: Jossey-Bass.

Kitchener, K.S., & King, P.M. (1981). Reflective judgment: Concepts of justification and their relationship to age and education. Journal of Applied Developmental Psychology (2), 89-116.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. American Educational Research Journal, 27, 29-63.

Lave, J. & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Lyons, Nona. (1990). Dilemmas of knowing: Ethical and epistemological dimensions of teachers' work and development. Harvard Educational Review, 60 (2), 159-180.

Mines, R.A., King, P.M., Hood, A.B., & Wood, P.K. (1990). Stages of intellectual development and associated critical thinking skills in college students. Journal of College Student Development, 31, 538-547.

Perry, W.G., Jr. (1970). Forms of intellectual and ethical development in the college years: A scheme. New York: Holt, Rinehart and Winston.

Perry, W.G., Jr. (1981). Cognitive and ethical growth: The making of meaning. In A. Chickering & Associates (Eds.), The modern American college (pp. 76-116). San Francisco: Jossey-Bass.

Pintrich, P.R. & De Groot, E.V. (1990). Motivational and self-regulated learning components of classroom academic performance. Journal of Educational Psychology, 82 (1), 33-40.

Pintrich, P.R. & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom academic tasks. In D. Shunk and J. Meece (Eds.), Student perceptions in the classroom (pp. 149-183). Hillsdale, NJ: Lawrence Earlbaum.

Pintrich, P.R., Smith, D.A., Garcia, T. & McKeachie, W.J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). Educational and Psychological Measurement, 53, 801-813.

Schoenfeld, A. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. Cognitive Science, 7 (4), 329-363.

Schoenfeld, A. (1988). When good teaching leads to bad results: The disasters of "well taught" mathematics classes. Educational Psychologist, 23, 145-166.

Schoenfeld, A. (1992). Learning to think mathematically: Problem solving, metacognition and sense making in mathematics. In D. A. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 334-370). New York: Macmillan.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 82 (3), 498-504.

Schommer, M. (October, 1992). Predictors of epistemological beliefs: Comparing adults with only a secondary education to adults with post secondary education. Paper presented at the Mid-Western Educational Research Association, Chicago.

Schommer, M. (1993a). Comparisons of beliefs about the nature of knowledge and learning among postsecondary students. Review of Higher Education, 34 (3), 355-370.

Schommer, M. (1993b). Epistemological development and academic performance among secondary students. Journal of Educational Psychology, 85 (3), 406-411.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so." Journal of Educational Psychology, 82, (4).

Schutz, P.A., Pintrich, P.R., & Young, A.J. (1993). Epistemological beliefs, motivation, and student learning. Paper presented at the American Educational Research Association, Atlanta.

Table 1

Mean Scores and Standard Deviations for Beliefs, Motivation, Learning Strategies, and Performance Measures for Total and by Instructional Group

	Total (n=435)		Traditional (n=349)		New Wave (n=86)	
	M	SD	M	SD	M	SD
Beliefs (0-6)[1]						
Math beliefs*	2.20	0.91	2.24	0.87	2.02	1.04
Simple beliefs*	2.32	1.22	2.38	1.20	2.09	1.27
Isolated beliefs	2.06	1.05	2.08	1.02	1.96	1.17
Motivation (0-6)						
Intrinsic	3.91	1.07	3.92	1.06	3.87	1.13
Self-efficacy	3.94	1.35	3.98	1.35	3.75	1.34
Learning Strategies (0-6)						
Self-regulation**	3.89	0.76	3.93	0.78	3.71	0.68
Elaboration	3.57	0.98	3.60	1.00	3.41	0.88
Performance Measures	(n=1693)		(n=1393)		(n=300)	
Course grade*** (0-4.3)	2.72	1.06	2.78	1.01	3.10	0.80
Final items* (0-10)	7.19	1.82	7.14	1.84	7.39	1.69

[1]High score indicates agreement with less sophisticated beliefs.
*Significant difference between treatment groups at .05 level.
**Significant difference between treatment groups at .01 level.
***Significant difference between treatment groups at .001 level.

Table 2

Correlations Between Beliefs and Motivation, Learning Strategies and Performance

Intrinsic Motivation

	Total n=428		Traditional n=344		New Wave n=84	
	r	p	r	p	r	p
Math beliefs	-.17	.001***	-.19	.001***	-.14	.10
Simple beliefs	-.05	.14	-.07	.09	.01	.46
Isolated Beliefs	-.24	.001***	-.23	.001***	-.25	.01**

Self-Efficacy

	Total		Traditional		New Wave	
	r	p	r	p	r	p
Math beliefs	-.13	.001**	-.14	.001***	-.12	.14
Simple beliefs	-.03	.29	-.03	.26	-.05	.36
Isolated Beliefs	-.19	.001***	-.21	.002***	-.16	.07

Self-Regulation

	Total		Traditional		New Wave	
	r	p	r	p	r	p
Math beliefs	-.16	.001*	-.22	.001***	-.02	.42
Simple beliefs	-.07	.08	-.13	.01**	.15	.08
Isolated Beliefs	-.21	.001***	-.22	.001***	-.21	.03*

Elaboration						
	Total		Traditional		New Wave	
	r	p	r	p	r	p
Math beliefs	-.04	.21	.02	.33	.07	.27
Simple beliefs	.08	.05*	.05	.20	.19	.04*
Isolated Beliefs	-.02	.31	.01	.40	-.09	.21

Common Final Items						
	Total		Traditional		New Wave	
	r	p	r	p	r	p
Math beliefs	.00	.48	-.03	.29	-.11	.16
Simple beliefs	.00	.42	-.03	.26	.10	.18
Isolated Beliefs	-.01	.46	-.01	.40	-.08	.24

Course Grade						
	Total		Traditional		New Wave	
	r	p	r	p	r	p
Math beliefs	-.09	.04*	-.10	.04*	.03	.39
Simple beliefs	-.06	.10	.06	.13	.02	.43
Isolated beliefs	-.08	.05*	-.09	.04*	.03	.39