DOCUMENT RESUME

ED 412 116		SE 060 671

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TITLE	Interest and Anxiety in Mathematics.
PUB DATE	1997-03-27
NOTE	41p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 27, 1997).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Educational Environment; Elementary Secondary Education; Interest Inventories; *Mathematics Anxiety; Mathematics Education; Sex Differences; *Student Interests; Student Motivation

ABSTRACT

This study investigated 36 mathematics classroom environments that a priori appeared to hold promise as being motivationally effective. Classroom environments from fifth grade through graduate school were selected (N=598 students). In particular, the study measured students' perceived situational interest in the learning environment, individual interest in mathematics (with pre and post measures), and mathematics anxiety (with pre and post measures). The results indicate that environments high in situational interest were associated with substantial increases in the mean individual interest of students and had a beneficial but smaller impact in terms of associated decreases in mathematics anxiety. In addition, there did appear some gender effects with females being more affected by the level of situational interest in mathematics. Finally, the environments appeared to be particularly effective for students with previously low individual interests in mathematics. The study enriches our understanding of the "interest" construct primarily by providing evidence that the situational interest of learning environments may have a much greater impact on individual interests than researchers previously thought. Teachers and practitioners may need to pay as much attention to the motivational effects of mathematics classrooms as they do to the learning effects. Students who have positive affective experiences will be more willing to continue taking mathematics courses or to pursue careers which utilize skill in mathematical thinking. Contains 17 references. (Author)

Interest and Anxiety in Mathematics

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March 27, 1997

A presentation at the Division C Poster Fair on Individual Differences in Science and Math Learning titled:
Interest and Anxiety in Mathematics
at the Annual Meeting of the
American Educational Research Association
in Chicago, IL

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This study investigated 36 mathematics classroom environments that *a priori* appeared to hold promise as being motivationally effective. Classroom environments from the fifth grade through graduate school were selected (N=598 students). In particular the study measured students' perceived situational interest in the learning environment, individual interest in mathematics (with pre and post measures), and mathematics anxiety (with pre and post measures). The results indicate that environments high in situational interest were associated with substantial increases in the mean individual interest of students, and had a beneficial but smaller impact in terms of associated decreases in mathematics anxiety. In addition, there did appear to be some gender effects--with females being more affected by the level of situational interest in a learning environment. Finally, the environments appeared to be particularly effective for students with previous low individual interests in mathematics. The study enriches our understanding of the "interest" construct primarily by providing evidence that the situational interest of learning environments may have a much greater impact on individual interests than researchers previously thought.

The paper argues that we may need to pay as much attention to the motivational effects of mathematics classrooms as we do to the learning effects. Students who have positive affective experiences will be more willing to continue taking mathematics courses or to pursue careers which involve skill in mathematical thinking.

Interest and Anxiety in Mathematics

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A number of students find mathematics classrooms boring, meaningless, and un-involving (Mitchell, 1993). This lack of motivation, in addition to key cognitive variables, helps to explain the low level of student competence in the subject. The report Everybody Counts: A Report to the Nation on the Future of Mathematics Education (National Research Council, 1989) stated, "Mathematics is the worst curricular villain in driving students to failure in school. When mathematics acts as a filter, it not only filters students out of careers, but frequently out of school itself" (p. 7). If a primary manifestation of boredom is a lack of interest in learning (Hidi, 1990), then one potential way to combat classroom boredom is to manipulate the motivational variable called "interestingness" (Hidi, 1990; Pintrich & Schunk, 1996; Schank, 1979).

Interest may be conceptualized as a variable which effects both motivational and cognitive activity. Hidi's (1990) review of interest research concluded that interest has a "profound effect on cognitive functioning and the facilitation of learning." (p. 565). The obvious explanation is that interested students spend more time on learning tasks. Yet research studies indicate that interested students do not consistently spend more (or less) time than other students on an instructional activity (Hidi, 1990). Instead, the key factor affected by interest appears to be *depth* of cognitive processing (Pintrich, 1989; Pintrich & Garcia, 1991; Pokay & Blumenfeld, 1990; Schiefele, 1991, 1992). It appears that students who report that their courses are more interesting are also more likely to employ deeper cognitive processing. Depth of processing behaviors reported in these studies included cognitive elaboration strategies, metacognitive control strategies, and engagement in critical thinking. These results suggest that if we can effectively raise the level of interest in the classroom then we may also increase the level of academic achievement for many high school students.

Within the context of mathematics classrooms, this study takes the view that there is a "primacy of motivation" effect. This viewpoint posits that motivational effects of learning environments are as important to consider as the learning effects. While this *primacy of motivation* (or PoM) argument may not be as viable in a literature course (where many of the students may already enjoy reading), in many mathematics courses we have reason to believe that students do not enter, or leave, as motivated learners of mathematical concepts. The critical consequence of this *primacy of motivation* effect is twofold: (1) students not learning as much as they would if they were more motivated, and (2) students electing not to take, or use, mathematics when given the choice. Human beings will tend to pursue skills and knowledge which they perceive as useful or enjoyable. One of the primary benefits of the *primacy of motivation* effect is that students who are highly motivated will be much more likely to learn new domains simply because it is enjoyable to do so. Furthermore, such highly motivated persons will be more likely to explore livelihoods which require further education in such a target area. In the domain of mathematics, many people cast themselves as "non-math" types at an early age. Thus, teachers and learning environments which are effective at increasing student motivation to learn mathematics are likely helping students in many ways (both academically and otherwise) by increasing students' interest in mathematical inquiry.

The term interest, as used in this study, has three key characteristics: (1) it is defined by a person-environment interaction, (2) it develops due to both knowledge and value, and (3) within the school context, it refers to an interest directly tied to the goals of instruction. This definition of interest has been further elaborated elsewhere (see Renninger, Hidi, & Krapp, 1992). Figure 1 provides an overview of the multifaceted model of interest used as the basis for this study. This model initially distinguishes between individual interest and situational interest. Individual interest (II) describes the "person" component of the person-environment characteristic of interest. Individual interest is defined as the interest that a person brings to some environment or context. For instance, some students will come to a mathematics classroom already interested (or uninterested) in the subject--this represents an individual interest.

Insert Figure 1 about here

Individual interest is generally conceptualized as being both a disposition and an actualized state (Krapp, Hidi, & Renninger; 1992). A disposition implies an interest that is enduring. Thus individual interests are generally assumed to remain over long periods of time. The "actualized state" implies that individual interest becomes "actualized" or demonstrated in such behaviors as highly focused attention, displays of pleasure, and a high degree of persistence at a task. From an educational perspective, we would hope to have more students develop a greater II in mathematics. In particular, mathematics teachers need to be concerned with students not only learning mathematics but coming out of such courses with the disposition to *continue* learning and using mathematics.

Situational interest (SI) describes the "environment" component of the person-environment interaction. Situational interest is defined as an interest that "is generated primarily by certain conditions and/or concrete objects (e.g. texts, film) in the environment" (Krapp, Hidi, & Renninger; 1992, p. 8). For example, if a classroom activity is developed that a student finds interesting (given there was no pre-existing II in the activity), this represents a situational interest. Situational interest is thought to have two key characteristics. First, the initial environmental context that elicited the interest (e.g. a text or a presentation) will be present only for a short time. Thus, once the interaction with the environmental context is gone, so is the situational interest (Hidi, 1990). Second, SI represents an interest which the majority of people in an environment experience. If learning environments are to be motivationally effective, they need to be perceived as high in SI for a substantial percentage of the students in the classroom.

II and SI are hypothesized to be related (Hidi & Anderson, 1992). In fact, it has been theorized that SI can enhance II. In particular, it has been suggested (Hidi & Anderson, 1992) that if an individual is consistently exposed to a high SI environment, then that individual will likely develop an II in the content of that environment. Hidi and Anderson think that IIs develop slowly. This implies that extended exposure to a high SI environment is needed before a person's II will be affected. For example, teachers have no influence on their students' II level in a subject at the beginning of a school year. However, a consistently high SI classroom may cause a noticeable increase in the students' IIs by the end of the school year. Since SI is defined as a short term variable, an effective environment is able to maintain that high SI for a more or less continuous period of time. While this is simpler to state than to do, classroom interventions aimed at increasing student learning and motivation need to focus on creating an environment which is high in SI.

A third motivational variable is mathematics anxiety (Hembree, 1990). While researchers often distinguish between test anxiety and state anxiety, the bottom line is that anxiety tends to be associated with decreased overall motivation and decreased achievement relative to other students with lower levels of anxiety (whether state or test). It seems reasonable to posit that classroom environments which are high in SI will tend to be effective in decreasing anxiety while those low in SI will tend to result in increased student anxiety. In short, while there are a number of treatments that have been tested regarding the reduction of either test or state anxiety in mathematics, one effective tool is to create a high SI environment. In essence, such thinking predicts that if one builds the interest then the anxiety will wither.

The relationship, in general, between student affect and student achievement in mathematics has been tenuous. In a recent meta-analysis by Ma and Kishor (1997), they concluded that the overall weighted mean effect size between attitude toward mathematics and achievement in mathematics to be .12. This can be interpreted as a positive yet very weak relationship. Interestingly enough, however, they did find practically important effect sizes for African-American (.27) and Asian-American (.52) students between attitude and achievement. They do note certain limits to their study--including the rather general measures used for "attitude towards mathematics." However, it seems reasonable to conclude that the relationship between attitude and achievement is at best small.

While interest is a specific kind of "attitude" there have not been found to be any moderate-to-strong relationships between interest and achievement. For example, Schiefele (1992) found small-to-moderate correlation coefficients between II and knowledge across several studies. One of the limitations of the various interest research conducted is that researchers have not been able to collect data regarding *changes in interest*, if any, and its relationship with knowledge or achievement. Given the original hypothesis of Hidi (1990) that interest may spark deeper processing of learning, it seems tenable to propose that changes in interest (especially for low to average students) will be moderately related to subsequent achievement.

These suggested relationships between SI, II, mathematics anxiety, and mathematics domain knowledge can be summarized by the model presented in Figure 2 (with thanks given to Alexander, Jetton, and Kulikowich, 1995, for their model which served as the inspiration for this study's model). In short, the model predicts that in high SI environments there will be a positive change in II between the beginning of the class and the end of the course. Secondly, the model indicates that there will be a negative change in anxiety (i.e. a decrease) over the course. Finally, the model posits that there will be small but moderate increases in mathematical knowledge over classes that are either moderate or low in SI. This study will not address the domain knowledge component of the model. Instead it will look at the SI, II, and anxiety components in two classrooms which were anticipated to be high in SI. Secondly the study will take an initial look at gender differences in the pre-supposed high SI classrooms.

Insert Figure 2 about here

While there are general models of situational interest (see Alexander, Jetton, Kulikowich, 1995), there appear to be two general ways to create high SI environments in the mathematics classroom: meaningfulness and involvement (Mitchell, 1993). Involvement deals with the notion that students find environments more interesting when they are active participants. On a crass level, video games are very involving for many students while too many mathematics classrooms are perceived as un-involving because the student is simply sitting and listening to a teacher lecture. In short, involvement implies the student being a participant rather than a spectator. Many of the new mathematics reform curricula such as the Interactive Mathematics Project have been implicitly structured around the thinking of making mathematics learning more active, hands-on, and participatory.

The second general variable, meaningfulness, addresses the idea that learners find environments more interesting if they are able to connect the new material to knowledge/skills which they already find meaningful in their own lives. One of the common problems found in much mathematics instruction is that the curriculum often seems divorced from any use in the students' current life. The phrase, "You'll need it to get into college" has been invoked too often by mathematics teachers. Such responses, while likely true, do not address the perceived immediate needs of the students.

Research Questions

In the theoretical model presented in Figure 2, SI was proposed as a key variable that may explain a significant amount of students' experiences in the mathematics classroom. On the one hand, high SI environments should help increase the II and decrease the anxiety experienced by students. Conversely, low SI environments would tend to decrease II and increase anxiety. In addition, it seems reasonable that high SI environments would be associated with higher learning gains than students in low SI environments. This model served as the basis for the nine research questions investigated in this study. The questions pursued were:

1. What is the relationship between anxiety, II, and SI?
2. Does SI will explain an important percentage of the variance in post-II *after* pre-II and anxiety are already accounted for?
3. Will high SI environments substantially increase II?
4. Will high SI environments substantially decrease anxiety?
5. Will low SI environments substantially decrease II?
6. Will low SI environments substantially increase anxiety?
7. Do high SI environments have a particularly beneficial effect on students with low pre--II scores? In other words, are highly interesting environments particularly helpful for students who have little previous interest in mathematics?

8. Are there gender differences with regards to the previous questions?
9. How are standardized learning gains associated with SI environments?

In the results presented below only a preliminary analysis of the questions is presented. Furthermore, the ninth question is not addressed at all as data collection regarding standardized learning gains will not be completed until mid-June 1997.

METHODOLOGY

This section first provides a description of the samples of classrooms and students included in the study. Next, the instrumentation and procedures used in the study are described. Finally, the analysis used for the data collected is given.

Sample

This paper looks at the results collected from 598 students in 36 classrooms taught by 25 different teachers in mathematics learning environments from the fifth grade through graduate level. Six fifth grade teachers were used, 2 sixth grade teachers, 4 seventh grade teachers, 5 eighth grade teachers, 1 ninth grade teacher, 3 tenth grade teachers, 1 undergraduate level instructor, and 3 doctoral level instructors in Applied Educational Statistics. While the majority of the data was collected between August and December of 1996, approximately 15% of the data was collected in the period between August 1994 and August 1996.

All of the teachers and classrooms surveyed were pre-identified as more-than-likely to be high in SI. Sometimes teachers were identified because of information we had about them personally, others were identified because they appeared to be implementing a unique curriculum, and finally other instructors were identified because of their standing in highly regarded public or private schools. Of course not all of these classroom environments were indeed high in SI, but by "stacking the deck" we hoped to maximize our chances of finding, from the student perspective, classrooms that evidently were successful in creating a high level of situational interest for a sustained period of time.

Sampling was somewhat problematic in that pre and post measurements were taken approximately 14-16 weeks apart. Some students were not present at the first measurement time, but were at the second. Conversely, some students were present at the first, but not the second. Other students put inconsistent names on the surveys so that accurate matching could not occur. In some classes, students were allowed to use a "make believe" name as long as they could remember it. Inevitably some forgot, despite the survey administrator bringing along a sheet of code names used at the first measurement time. All of these problematic features typically led to complete data being collected on only about 50% of the students in a few of the classes. However in many cases we collected complete data on approximately 90% of the students a class. Most importantly, there is no reason to believe there was any systematic bias in the final sample. Instead the sampling was more influenced by the uncontrollable factors of illness, students switching classes, or faulty memory.

Instrumentation and Procedures

The intent of the study was to determine the level of SI in a variety of classroom environments. Furthermore the study wanted to look at the relationship between classroom SI on changes in individual interest and mathematics anxiety. The instrument used for measuring students perceptions was the Interest Survey (or IS). The reliability and basic construct validity of the instrument had been assessed in a previous study (Mitchell, 1993). The instrument contained three scales. These scales measured: (1) individual interest in mathematics (II), (2) mathematics anxiety, and (3) situational interest level of the classroom (SI).

The items in the IS were constructed using a Likert scale. Students responded to a 6-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (6). Each of the scales was composed of 4 to 5 items with approximately half positively worded, half negatively worded. An example of an item from each of these three scales respectively are provided below.

I think mathematics is really boring. (II)
strongly agree agree slightly agree slightly disagree disagree strongly disagree

Our math class is fun. (SI)
strongly agree agree slightly agree slightly disagree disagree strongly disagree

When I am in math class, I usually feel very much at ease and relaxed. (Anxiety)
strongly agree agree slightly agree slightly disagree disagree strongly disagree

Data collection began in September 1994 and continued through December 1996. For each classroom, the pre-survey (which included no SI items) was given on the first day of class. This survey took 15 minutes of class time to explain, students complete, and to be collected. The post-survey was given in the last week of each class. This post-survey took 15-20 minutes of class time to administer. Students were allowed to use either their real or a fictitious name on the surveys. Data was entered into a computer where a unique ID number was given to each subject.

Data on subjects were collapsed across classes as long as the subjects all had the same instructor in the same titled course (e.g. "10th grade Geometry"). Previous findings (Mitchell, 1993) indicate no significant differences between classroom environment ratings for the same instructor teaching the same class. In short, instructors are very effective at creating "an environment" for a specific course of study. These environments are perceived in a very similar manner even when the course is given to different groups of students in different semesters. The advantage of collapsing the data is that it provided the study with greater power.

In addition, for all of the seventh and eighth grade subjects we are collecting learning score indicators. We have collected each student's standardized mathematics score at the end of their previous year of schooling, and in June 1997 will have their standardized score for their current year of schooling. All the seventh and eighth grade students in this study have one teacher for a whole school year. In addition we have collected teacher grading information. Yet it will not be till mid-June 1997 that we will be able to incorporate measures of standardized learning gains into our analysis using the 7th and 8th grade subsample.

Analysis

When looking at student perceptions (whether interest or otherwise) it is important not to be too simplistic. In other words, how do we operationally define a high SI environment? One could use a criterion standard (e.g. "All classrooms with average SI ratings above 4.0 will be considered high."). Yet this can be highly problematic. Consider the case of a remedial mathematics class full of students will a low II in mathematics. In such a room full of turned-off students, even the most exciting SI environment may not get a high SI criterion rating. What seems to be more important is that an effective SI environment is one which is perceived as being noticeably higher than the students' mean pre-II. Thus, it would be reasonable to conjecture that in such cases students' *post*-II will tend to move towards that higher SI rating.

Given this line of thinking, high SI was operationally defined as a classroom environment in which the mean SI rating was noticeably higher than the mean pre-II rating for a particular student. Specifically, a class was considered high in SI if the difference between the mean SI rating and the mean pre-II rating for a teacher was an effect size difference greater than .20.

All the analyses conducted for this paper were considered preliminary. In many cases a more complete, or advanced, approach will be used in the final analysis when data collection is fully completed in June 1997. The first two research questions were assessed by looking at simple correlations and conducting a multiple regression analysis (MRA). Research questions three through eight were assessed through the use of descriptive mathematics and effect size measures.

RESULTS

The reliability of the 3 scales used in the study were assessed by calculating the internal consistency coefficients (Cronbach's alphas) for each scale. The internal consistency coefficient for situational interest ranged from .86 to .93 across various classroom environments. The internal consistency coefficient for both pre-individual interest and post-individual interest ranged from .81 to .92 across various classroom environments. Finally, the internal consistency coefficient for both pre-anxiety and post-anxiety ranged from .72 to .92 across various classroom environments. For purposes of a psychometric instrument, alpha coefficients of at least .70 would be desired (Nunally, 1978). As the results indicate, all of the scales have a more than satisfactory coefficient.

All further analyses using the items were done by creating scales for each of the 3 constructs. Each scale was created by calculating the average response per item in the scale. Thus all results are presented with a 1 representing the minimum score, 6 the maximum score, and 3.5 the midpoint. There were 5 scales created. Two scales measured II at the pre and post measurement times, two scales measured mathematics anxiety at the pre and post measurement times, and the scale for SI was measured at the post measurement time.

The study's first question asked whether there is a relationship between anxiety, II, and SI. Table 1 (below) provides the correlational results. Not surprisingly, there are high correlations between the pre and post measures for anxiety (.68) and for II (.73). In general, the relationships between either of the measures of anxiety with either measure of II or with SI is negative and in the small to moderate range. The strongest of these relationships is that between pre-

II and pre-Anxiety with r=-0.54. SI had a relatively low relationship with either time measure of Anxiety (-0.25 and -0.35), a moderate association with pre-II, but a very high relationship with post-II. In fact, the relationship between SI and post-II is higher than the correlation between pre- and post-II (r=.80 to r=.73). While not shown in Table 1, this general structure of relationships held when analyzing correlation coefficients within high, moderate, or low SI environments.

Table 1 also presents the same set of correlations when the file was split by gender. The pattern of results show relatively few differences between males and females. The most outstanding difference appears to be that for females there is a weaker relationship between anxiety and the II and PI measures than with males. However, in both genders the relationship between post-II and SI is positive and strong and more impressive than the pre-II and post-II correlation.

Insert Table 1 about here

The second research question looks at how much additional variance in post-II will be explained by SI *after* pre-II and anxiety are already entered in a multiple regression analysis. We know from Table 1 that SI has an even higher correlation with post-II than does pre-II. Nonetheless, if SI is a motivationally effective variable then it should still be able to explain an important additional amount of variance in post-II scores after pre-II and anxiety have been accounted for. Table 2 shows the results of the MRA analysis. The table shows the "value-added" aspect of SI since it accounts for an additional 21% of the post-II variance. There was a noticeable gender difference, with SI explaining an additional 18% of the post-II variance for males but explaining an additional 24% of the variance for women (in all cases the F-test for the $R^2_{increase}$ was significant for SI). These results indicate that SI helps explain an important amount of the variance in post-II scores and furthermore that SI appears to have greater explanatory power for female students.

Insert Table 2 about here

Research questions three through seven address the heart of the study: what is the impact (if any) of high or low SI environments on II and anxiety? Table 3 (below) gives a relatively detailed account of the key variables within each type of SI environment (high, moderate, and low) and within each specific classroom environment. Standard deviations are not provided in Tables 3-6, but generally the standard deviations for the variables run between .85 and 1.15 except in a very few cases. Table 3 provides the means, within classroom environments, for SI only. The next three columns present information in terms of effect size. First, the SI and pre-II effect size difference is presented. Remember, that a high SI environment was defined as one in which this effect size is .20 or greater (similarly, low SI environments are ones in which the effect size is -.20 or lower with the moderate SI environments incorporating all the other classrooms). There is one anomaly that is worth noting in Table 3. Some classrooms in the "moderate" category seem to have a relatively high SI rating. However, the difference between this SI rating and the incoming II of the students is not great. Of course, if one has a classroom full of eager mathematics learners (e.g. the grade 8, teacher 2 environment), then a teacher may still be doing an outstanding job by simply maintaining the previous level of mathematical interest of their students. Nonetheless, the focus of this study was on classroom environments that appeared capable of *increasing* II.

Insert Table 3 about here

Table 4 (below) presents more general information that helps to address the 3rd through 7th research questions. This table is structured in a similar fashion to Table 3 except that results are presented by high, moderate, and low SI environments *and* by high, moderate, and low II types of students. Students were operationally defined as having a high pre-II if their score was 4.0 or greater, low if their score was 3.0 or lower, and moderates incorporated all other scores. In addition, this table provides the pre-II and post-II means.

In terms of question #3, the results in Table 4 do suggest that high SI environments are associated with increases in II. In fact, overall II increased by an effect size of .42--a moderate effect size gain. In terms of question #4, it appears that anxiety in high SI environments had an overall decrease by an effect size of -.29--a small effect size decrease. Research questions 5 and 6 look at the impact of low SI environments. Table 4 indicates that low SI environments are associated with negative but small effect size decreases in II (Δ=-0.21) and with negative small effect size decreases in anxiety (Δ=-0.11).

Question seven looks at whether high SI environments have a particularly beneficial effect on students with low pre-II scores. Table 4 indicates that for these "low" students in high SI environments that the effect size gains in II are indeed impressive (Δ=.89) while the anxiety decreases are also impressive (Δ=-0.69). In fact, the apparent influence of high SI environments on "moderate" pre-II students is almost equally impressive in terms of II effect size gains (Δ=0.79) but substantially lower in terms of anxiety decreases (Δ=-0.21). While not hypothesized previous to the study, there also appears to be important changes when high or moderate pre-II students are put in *low* SI environments. Specifically, those high pre-II students experience moderate decreases in II (Δ=-0.63) with almost no change in anxiety. Similarly, the moderate pre-II students experience small decreases in II (Δ=-0.18). Ironically enough, low pre-II students experiences small effect size gains in II (Δ=.24)!

Insert Table 4 about here

The eighth research question asks whether there are gender differences with regards to the previous questions. Gender differences with regards to the correlational analyses have already been addressed. However Tables 5 and 6 present evidence with regards to the relationship between gender and SI. Recall that the MRA indicated that SI may have more of an impact on females than males. The results presented in Table 5 continue that theme. Females appear to experience greater gains in II than males in high SI environments (Δ=.57 for females to Δ=.39 for males). However, males seem to experience greater decreases in anxiety than females in high SI environments (Δ=-.44 for males and Δ=-.31 for females). These results follow the same pattern in low SI environments where females experience a greater decrease in II, but males still experience the greater decrease in anxiety. Table 6, which provides greater detail than Table 5, confirms these general trends.

Insert Table 5 about here

Insert Table 6 about here

Our final question regarding the relationship between SI, II, and anxiety on learning gains remains unanswered at this time. In June we will be able to assess this relationship using all the seventh and eighth grade students for whom we will have collected standardized math achievement scores both before and after their academic school year.

SUMMARY AND CONCLUSION

The preliminary analyses of the evidence collected so far provide some clear answers, some ambiguities, and some surprises. First, highly interesting environments appear to result in increased individual interest on the part of students. Conversely, low SI environments are associated with decreases in II. These results conform with the theoretical model of SI presented in Figure 2. However, the results with regards to mathematics anxiety are more mixed. In a very general way, high SI environments seem to be associated with small decreases in anxiety. However the pattern with moderate and low SI environments do not fit the predictions made in the original model. In short, anxiety does not appear to have as high an association with SI as was theorized. Females, surprisingly, appear to be much more highly influenced by the "interestingness" of the learning environment than males. In addition, high SI environments appear to be especially effective for low and moderate pre-II students. Surprisingly, high pre-II students do not appear to be immune to the effects of low SI environments. In fact, the results indicate that high pre-II students in low SI environments experience rather drastic reductions in their II for mathematics.

One could counter that such results are not terribly surprising. In some ways such comments are appropriate. However, it is useful to look at the ways in which these results help provide evidence which sheds new light on: (1) previous theoretical thinking about the nature of interest and (2) the power of learning environments in general.

Previous thinking about the nature of individual interest is subject to a number of interpretations (see Renninger, Hidi, & Krapp, 1992). Yet most interest researchers consider individual interest to be a relatively stable, hard-to-change, motivational variable. This would be considered especially so when considering adolescents or adults. Although Hidi and Anderson (1992) have posited that SI may well be powerful enough to change II, there has been little data collected to shed light on the tenability of their position. Beyond their theoretical point is the practical issue of "how long" does it take for SI to exert a positive influence on II (if it exerts any influence at all)? The results from this study suggest that high SI environments can raise the mean II of students by half a standard deviation or greater (with effect size changes in II for low and moderate pre-II students of .89

and .79 respectively). Moreover, these types of changes can occur in the range of 14-16 weeks of academic instruction. Thus the initial results indicate that we may have to re-think the relatively stable, unchangeable nature of individual interest.

Furthermore, the results from this study are essentially optimistic since they indicate that learning environments do make a difference. Individual interests can certainly be increased in a high SI environment. Furthermore, it appears that mathematics anxiety also decreases in small-to-moderate amounts in high SI environments. In addition, low SI environments also have a powerful influence. It appears that low SI environments are particularly adept at decreasing II--most especially in students who came in with an initially high II! While this study did not measure learning outcomes and relate them to the motivational variables used, it is hard to believe that an increased II would lead to decreased achievement. What has yet to be uncovered, however, is whether high SI environments are effective at increasing achievement. Yet learning environments do appear to have considerable influence on previous motivational attitudes students bring with them into the classroom.

Most central to this study, however, is the role well-designed mathematics courses may have on students' future academic decisions. That is, even if we are left ignorant about the relationship between interest and achievement, it is proposed that there is a certain *primacy of motivation* which posits that interest, in and of itself, is an important factor for mathematics educators to consider. For example, at the high school level we know that mathematics courses all too often function as a "filter" rather than as a "pipeline" for future academic opportunities. Moreover, the nature of high SI classes might help motivate students to continue taking mathematics courses--perhaps resulting in more students electing to major in mathematics or mathematics-related fields at the college level.

If a significant number of students actually find mathematics or mathematics classrooms as boring, meaningless, and un-involving it is important that we pay closer attention to their motivational experiences. In this case, numbers are likely not lying. Instead they may be asking us to reconsider how we teach mathematics, and to provide more meaningful and involving learning experiences. While there are likely many effective ways to enhance students' motivation, it does behoove us to have a better understanding of what makes effective mathematics classrooms "tick" and to learn from the successful experiments that are *already* being implemented in schools and colleges. Towards that end one of the future aspects of this ongoing study will be to conduct focus groups and teacher interviews with students and teachers from this study's identified high SI classroom environments. We hope that such an analysis of such rich qualitative data will provide us with better insights into some of the "best practices" that appear to result in increased student motivation to learn mathematics.

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Figure 1. Model of the Interest Construct

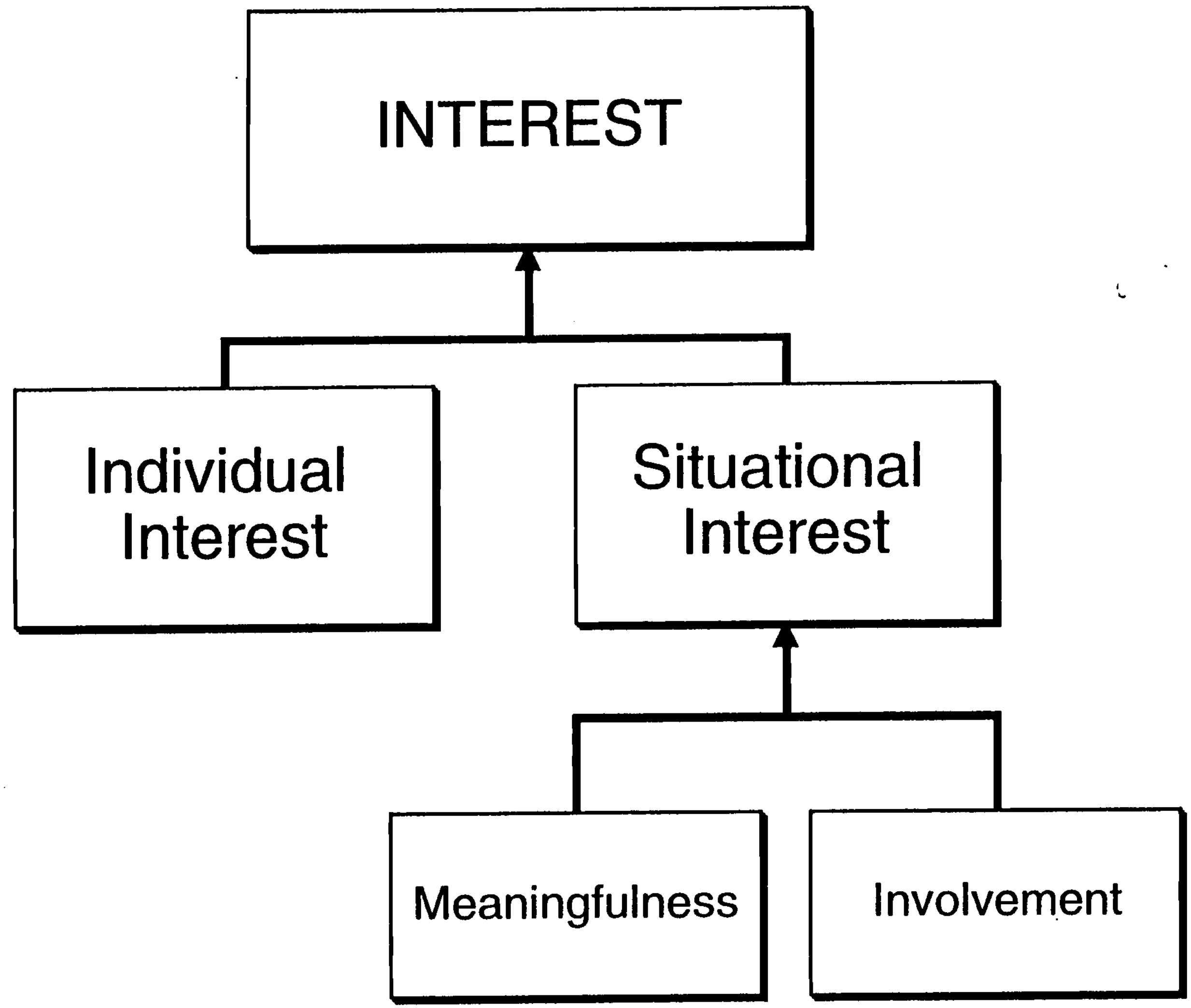

Figure 2. A Model of Situational Interest for Mathematics

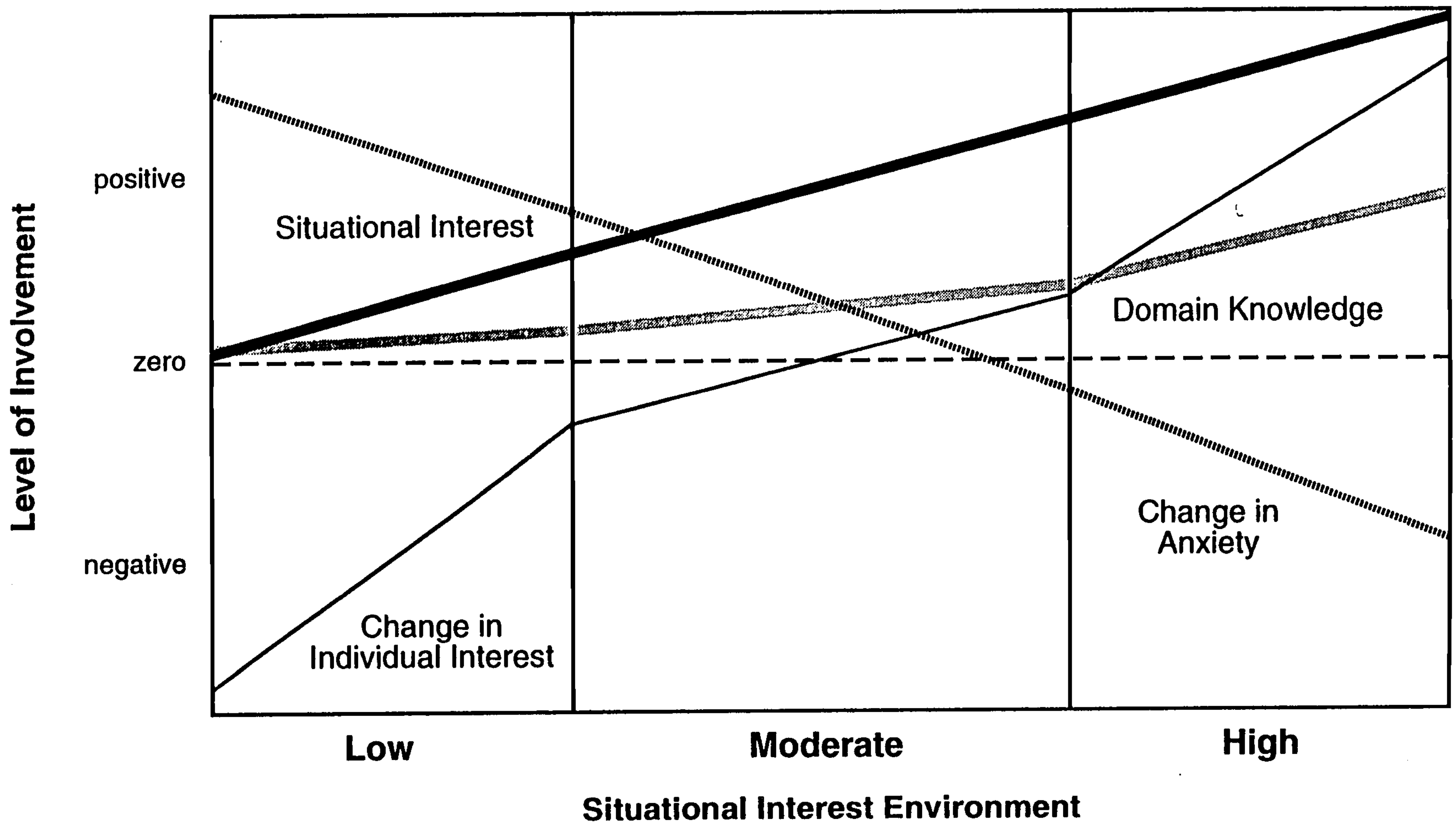

Table 1. Correlational Results.

TOTAL SAMPLE (N = 598)

	Pre Anx	Post Anx	Pre II	Post II	SI
Pre Anx	1				
Post Anx	0.68	1			
Pre II	-0.54	-0.45	1		
Post II	-0.38	-0.45	0.73	1	
SI	-0.25	-0.35	0.54	0.80	1

Males (n1 = 220)

	Pre Anx	Post Anx	Pre II	Post II	SI
Pre Anx	1				
Post Anx	0.70	1			
Pre II	-0.59	-0.58	1		
Post II	-0.47	-0.62	0.79	1	
SI	-0.37	-0.54	0.67	0.86	1

Females (n2 = 378)

	Pre Anx	Post Anx	Pre II	Post II	SI
Pre Anx	1				
Post Anx	0.66	1			
Pre II	-0.50	-0.37	1		
Post II	-0.31	-0.33	0.69	1	
SI	-0.16	-0.22	0.44	0.75	1

Table 2. MRA Results.

Multiple Regression (DV = Post II)

TOTAL SAMPLE (N=598)

Overall	Total R^2	R^2 Increase	B
Pre II	0.54		0.41
Anx Diff	0.57	0.04	-0.10
SI	0.78	0.21	0.55
		Constant	0.26

Males	Total R^2	R^2 Increase	B
Pre II	0.64		0.36
Anx Diff	0.68	0.04	-0.09
SI	0.85	0.18	0.61
		Constant	0.27

Females	Total R^2	R^2 Increase	B
Pre II	0.46		0.43
Anx Diff	0.49	0.03	-0.09
SI	0.73	0.24	0.52
		Constant	0.27

Correlation Matrix

	Post II	Pre II	Anx Diff	SI
PostII	1			
PreII	0.73	1		
AnxDiff	-0.14	0.07	1	
SI	0.78	0.52	-0.16	1

Table 3. Classroom Descriptive Results.

High SI Environments

Grade	Teacher	SI	SIII Diff	II Diff	Anx Diff	N
16	1	4.67	1.66	0.67	n/a	14
8	4	4.97	1.07	0.56	-0.50	8
19	4	4.52	0.55	0.64	-0.36	44
10	11	3.75	0.48	0.48	-0.40	26
7	3	4.02	0.38	0.59	-0.26	16
7	1	4.33	0.31	0.26	-0.28	19
8	3	4.23	0.25	0.21	-0.54	12
					Count:	139

Moderate SI Environments

19	1	4.47	0.19	0.29	-0.19	15
5	6	4.52	0.14	0.10	-0.25	16
7	2	3.77	0.08	0.10	-0.27	17
5	4	2.79	-0.02	0.21	-0.11	18
6	1	4.34	-0.03	-0.06	0.45	16
10	1	3.69	-0.03	-0.18	-0.26	31
10	12	2.91	0.04	0.06	-0.28	22
9	5	3.47	0.17	0.03	0.36	21
8	2	4.32	-0.05	0.12	0.08	33
5	3	3.90	-0.06	0.11	0.09	23
8	5	4.38	-0.11	0.14	-0.46	27
					Count:	239

Low SI Environments

5	1	3.44	-0.23	0.03	0.09	20
5	2	4.06	-0.29	-0.08	-0.11	23
19	2	3.11	-0.43	-0.50	-0.17	7
8	1	3.32	-0.40	-0.05	0.60	27
7	4	3.07	-0.59	-0.18	-0.32	45
5	5	3.51	-0.67	-0.39	0.09	41
6	2	2.93	-0.80	-0.48	-0.09	43
9	1	3.75	-1.06	-0.64	0.25	14
					Count:	220
					TOTAL:	**598**

One variable (SI) is given in scale units (where 1 is low, 6 is high, 3.5 is the midpoint of the scale). The other three variables (SIPI Diff, PI Diff, and Anx Diff) are given in terms of effect size units. Effect sizes were calculated by taking the mean of the difference scores divided by the standard deviation of the difference scores for each of these 3 variables.

SIPI Diff refers to the difference between the student's perceived SI of a classroom environment relative to their incoming PI at the beginning of the course or semester.

Table 4. SI Environment Descriptive Analysis.

SI Type	II Type	SI	SIII Diff	II Diff	Anx Diff	Pre II	Post II	N
High	Low	3.73	1.42	0.89	-0.69	2.23	3.07	42
High	Moderate	4.43	1.07	0.79	-0.21	3.68	4.21	53
High	High	4.71	-0.33	-0.20	-0.27	5.01	4.90	44
	TOTAL	*4.31*	*0.64*	*0.42*	*-0.29*	*3.66*	*4.08*	*139*
Moderate	Low	2.83	0.55	0.54	-0.17	2.20	2.75	65
Moderate	Moderate	3.76	0.04	0.05	0.03	3.72	3.77	71
Moderate	High	4.60	-0.55	-0.37	-0.09	5.05	4.82	103
	TOTAL	*3.87*	*-0.01*	*0.06*	*-0.07*	*3.88*	*3.94*	*239*
Low	Low	2.52	0.19	0.24	-0.07	2.35	2.58	54
Low	Moderate	3.22	-0.61	-0.18	-0.30	3.76	3.63	72
Low	High	3.89	-1.06	-0.63	-0.04	5.04	4.52	94
	TOTAL	*3.34*	*-0.62*	*-0.21*	*-0.11*	*3.96*	*3.75*	*220*

Three variables (SI, Pre PI, and Post PI) are given in scale units (where 1 is low, 6 is high, 3.5 is the midpoint of the scale). The other three variables (SIPI Diff, PI Diff, and Anx Diff) are given in terms of effect size units. Effect sizes were calculated by taking the mean of the difference scores divided by the standard deviation of the difference scores for each of these 3 variables.

TOTAL SAMPLE: 598

SIPI Diff refers to the difference between the student's perceived SI of a classroom environment relative to their incoming PI at the beginning of the course or semester.

Table 5. SI by Gender Analysis.

SI Type	Gender	SI	SIII Diff	II Diff	Anx Diff	Pre II	Post II	N
High	Male	4.19	**0.33**	**0.39**	**-0.44**	3.80	4.12	46
High	Female	4.36	**0.71**	**0.57**	**-0.31**	3.60	4.07	93
								139
Moderate	Male	3.80	**-0.06**	**0.06**	**-0.08**	3.86	3.91	104
Moderate	Female	3.93	**0.03**	**0.08**	**-0.07**	3.89	3.97	135
								239
Low	Male	3.45	**-0.38**	**-0.06**	**-0.22**	3.88	3.82	70
Low	Female	3.28	**-0.66**	**-0.33**	**-0.08**	4.00	3.72	150
								220

TOTAL SAMPLE: 598

Three variables (SI, Pre PI, and Post PI) are given in scale units (where 1 is low, 6 is high, 3.5 is the midpoint of the scale). The other three variables (SIPI Diff, PI Diff, and Anx Diff) are given in terms of effect size units. Effect sizes were calculated by taking the mean of the difference scores divided by the standard deviation of the difference scores for each of these 3 variables.

SIPI Diff refers to the difference between the student's perceived SI of a classroom environment relative to their incoming PI at the beginning of the course or semester.

Table 6. SI by II by Gender Analysis.

SI Type	II Type	Gender	SI	SIII Diff	II Diff	Anx Diff	Pre II	Post II	N
High	Low	Male	3.47	1.02	0.73	-1.02	2.19	2.92	13
High	Moderate	Male	4.24	0.98	0.69	-0.34	3.73	4.14	18
High	High	Male	4.74	-0.51	-0.27	-0.18	5.29	5.13	15
									46
High	Low	Female	3.84	1.67	0.96	-0.58	2.25	3.14	29
High	Moderate	Female	4.52	1.15	0.84	-0.12	3.66	4.25	35
High	High	Female	4.70	-0.22	-0.15	-0.28	4.86	4.78	29
									93
Moderate	Low	Male	2.53	0.39	0.43	-0.05	2.09	2.53	30
Moderate	Moderate	Male	3.70	0.08	0.01	0.04	3.64	3.65	26
Moderate	High	Male	4.64	-0.54	-0.24	-0.19	5.09	4.92	48
									104
Moderate	Low	Female	3.08	0.69	0.64	-0.27	2.30	2.93	35
Moderate	Moderate	Female	3.79	0.03	0.08	0.03	3.77	3.83	45
Moderate	High	Female	4.57	-0.56	-0.49	-0.01	5.01	4.73	55
									135
Low	Low	Male	2.46	0.32	0.50	-0.18	2.10	2.65	20
Low	Moderate	Male	3.14	-0.73	-0.26	-0.21	3.81	3.61	24
Low	High	Male	4.50	-0.82	-0.56	-0.24	5.30	4.90	26
									70
Low	Low	Female	2.55	0.07	0.05	-0.03	2.50	2.54	34
Low	Moderate	Female	3.27	-0.56	-0.15	-0.35	3.73	3.64	48
Low	High	Female	3.66	-1.17	-0.66	0.06	4.93	4.37	68
									150

Three variables (SI, Pre PI, and Post PI) are given in scale units (where 1 is low, 6 is high, 3.5 is the midpoint of the scale). The other three variables (SIPI Diff, PI Diff, and Anx Diff) are given in terms of effect size units. Effect sizes were calculated by taking the mean of the difference scores divided by the standard deviation of the difference scores for each of these 3 variables.

TOTAL SAMPLE: 598

SIPI Diff refers to the difference between the student's perceived SI of a classroom environment relative to their incoming PI at the beginning of the course or semester.

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