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ABSTRACT

This study investigated two statistics classroom environments that "a priori" appeared to hold promise as being motivationally effective classrooms. One environment (2 classes totaling 51 students) was at the high school level and the other environment (4 classes, 70 students) was at the graduate level. The study focused on students' perceived interest in the learning environment, individual interest in statistics (with pretest and posttest measures), and mathematics anxiety (also with pretest and posttest measures). Results indicate that both environments were high in situational interest, did substantially increase the mean individual interest of students, and had a beneficial, but small, impact in terms of associated decreases in mathematics anxiety. In addition, there did appear to be some gender effects, although these were not consistent across the two learning environments. Finally, it is noted that the environments appeared to be particularly effective for students with previous low individual interest in statistics and mathematics. The study enriches understanding of the construct of "interest" by providing evidence that the situational interest of learning environments may have a much greater impact on individual interests that researchers previously thought. It may be necessary to pay as much attention to the motivational aspects of statistics instruction as to the learning effects. (Contains 3 figures, 4 tables, and 17 references.) (Author/SLD)

Situational Interest in the Statistics Classroom

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Situational Interest in the Statistics Classroom

ABSTRACT

This study investigated two statistics classroom environments that *a priori* appeared to hold promise as being motivationally effective classrooms. One environment (2 classes) was at the high school level and the other environment (4 classes) was at the graduate level. In particular the study measured students' perceived situational interest in the learning environment, individual interest in statistics (with pre and post measures), and mathematics anxiety (with pre and post measures). The results indicate that both environments were high in situational interest, did substantially increase 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--although these effects across the two learning environments were not consistent. Finally, the environments appeared to be particularly effective for students with previous low individual interests in statistics/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 that researchers previously thought.

While only two specific learning environments are provided as examples, the paper argues that we may need to pay as much attention to the motivational effects of statistics classrooms as we do to the learning effects. Students who have positive affective experiences will be more willing to continue taking mathematics/statistics courses or to use quantitative analysis techniques in their own research.

Situational Interest in the Statistics Classroom

March 25, 1997

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.

More importantly, 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* argument may not be as viable in a literature course (where many of the students may already enjoy reading), in many statistics courses we have reason to believe that students do not enter, or leave, as motivated learners of statistical 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, statistics when given the choice.

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 statistics 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 statistics. In particular, educational statisticians need to be concerned with students not only learning statistics but coming out of such courses with the disposition to *continue* learning and using statistics.

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 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. 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 class. 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

<u>The Structure of Situational Interest</u>

While there are general models of situational interest (see Alexander, Jetton, Kulikowich, 1995), in this paper a specific model of situational interest in mathematics classrooms is presented. In short, there appears 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 study of statistics seems to lend itself well to classroom activities which invite a high level of involvement from students. Involvement might revolve around the collecting of primary data, analysis of data through the use of computers, or through discussions and debates regarding the findings from a study. In general the high school classroom setting may lend itself more to involving activities than the undergraduate or graduate classroom. Many high school courses can be structured in such a way that a slower and deeper understanding of the material can be gained. In many universities the real-life demands of a specified body of knowledge to be learned in a rather limited amount of time often encourages instructors to not implement student involvement activities in the classroom. While there are certainly exceptions, the old dilemma of "hands on" learning being effective but more time consuming often results in faculty choosing to opt for more time efficient modes of learning.

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.

Fortunately, one area of mathematics which lends itself particularly well to helping students create meaningful bridges between the topic and their own lives is statistics. For graduate students statistics is often meaningful simply because they are becoming initiated into the research community--and it is expected that researchers are able to interpret (if not always use) statistical methods. Yet even at the secondary and undergraduate levels, statistics offers a very powerful bridge for creating meaning. In essence statistics could be said the mathematics of extracting patterns from a body of data. Students know they live in a complex world where consensus is an ideal rather than a reality. Yet the world demands people to take action even in the absence of perfect information. Statistical methods offer students one way to help make sense of such data. Furthermore statistics is a very elastic subject that allows teachers to make bridges with a variety of subjects from social environmental issues to psychological research to current issues. In the end, students perceive mathematical classrooms which are more meaningful as higher in SI.

METHODOLOGY

This section first provides a description of the two classroom environments used in this study. Second, the specifics regarding the samples of students used is given. Third, the instrumentation and procedures used in the study are described. Fourth the research questions guiding the study are stated. Finally, the analysis used for the data collected is provided.

Classroom Environments

Two classroom environments were investigated in this study. The first involved tenth graders using a novel mathematics curriculum on statistics over a 14 week period. The second environment involved beginning doctoral students in a graduate school of education taking a required introductory course in statistics for one semester. A description of these two courses, as well as the theoretical rationale for including them in the study, is provided below.

The Statistical Thinking curriculum was designed for tenth grade students. The curriculum covered the concepts of central tendency, variance, z-scores, effect sizes, correlation, and simple linear regression. Most of the curriculum was computer-based and used the spreadsheet program Microsoft EXCEL. The main product students created was called a *teaching sheet:* an interactive spreadsheet developed for use by a "novice" in order to learn the particular statistical concept under study. Teaching sheets contained three key ingredients: (1) text, sound, or graphics that give a *storyline* explaining the purpose and importance of the statistical concept, (2) a well organized *number playground* where the user could try out various combinations of data and see the effects on the resulting statistical calculation, and (3) a *visual representation* of the statistical concept. An example of a *teaching sheet* is provided in Figure 3. Due to the heavy emphasis on learning a spreadsheet program and on creating the teaching sheets, it was anticipated that the Statistical Thinking curriculum would be high in SI due to it being both involving and meaningful for students.

Insert Figure 3 about here

The second environment, a section of an introductory statistics course for doctoral level students in education, was taught by an instructor who emphasized the importance of connecting statistical numbers with interpretation and evaluation of an educational controversy. Students wrote a fair amount in this course. Specifically they completed 5 *Think Papers* and 2 *Research Papers.* Although the Research Papers were longer in length (5-8 pgs.) than the Think Papers (2-3 pgs.), they had a similar structure. First students were presented with an educational dilemma ("Cut out the arts?", "Direct instruction or whole language instruction for reading?") and provided statistical evidence. Students were then required to respond to the dilemma in a reasoned way which needed to incorporate the evidence presented. While computers were used in this environment, they were not given the fundamental role in creating meaning that computers served in the high school curriculum. Involvement was not anticipated to be as strong a variable in this course as it was in the class for tenth graders. However, the course orientation was such that it was anticipated that the writing assignments would be perceived as highly relevant (or meaningful) and would encourage more involvement from students than when doing more traditional tasks such as preparing for tests and quizzes.

Sample

This paper looks at the results from two specific learning environments which taught statistics and were pre-hypothesized to likely be high in SI. However, the data collected in these two environments is a subsample of a larger study. The complete study contains 598 subjects in which mathematics learning environments from the fifth grade through graduate level were surveyed.

The first environment, Statistical Thinking for tenth graders, was implemented in the Spring semester of 1995. The curriculum involved one teacher and two classrooms. In total there were 51 students in the two classrooms. The classrooms were part of a public high school in northern California. The community around the school was a low-middle class community, and the student body was 86% non-Caucasian (in particular the school body is approximately 30% Latino, 25% African-American, 31% Asian-American, and 14% Caucasian).

The second environment, doctoral level educational statistics, was implemented in four semesters beginning with the Fall 1994 semester and ending with the Summer 1996 semester. There were 70 students total attending this course when all four semesters were added together. The university is private, the average age of the students are 40, and approximately 35% of the students are non-Caucasian.

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. 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 particular class. However, there is no reason to believe there was any systematic bias in this 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 if the two classroom environments would be effective in creating high SI environments. If they were successful, then the study wanted to look at the impact of these high SI environments 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 has continued through July 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. Previous findings (Mitchell, 1993) indicated 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 very similar ways 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. The total usable sample for the tenth grade environment was 26 students (out of 51). The total useable sample for the doctoral students was 44 students (out of 70).

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 six research questions investigated in this study. The questions pursued were:

1. Were, in fact, the two learning environments high in 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 a high SI environment substantially increase II?
4. Will a high SI environment substantially decrease anxiety?
5. Are there gender differences with regards to the previous questions?
6. 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?

No information was included on learning outcomes as respondents were allowed to use fictitious names to insure anonymity. This made the collection of achievement data impossible.

<u>Analysis</u>

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. This criteria was used for assessing the first research question. The other research questions were investigated through the use of multiple regression analysis or the descriptive use of effect size measures. Alongside each effect size measure is the p-value of the corresponding paired t-test conducted on the respective dependent 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 sample used for this particular study was a subsample of an overall sample of subjects measured using these scales. Thus reliability coefficients are based on calculations using classrooms from the entire sample (N=598) are presented. 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 first research question asked whether the two learning environments pre-identified as being high in SI were indeed high situational interest environments. Table 1 (below) provides the basic descriptive statistics. The initial evidence appears mixed. The high school sample had an SI rating with mean (standard deviation) of: 3.75 (1.16). Since the midpoint of the scale is 3.5, this number appears to be unimpressive. The graduate sample had an SI rating with mean (s.d.) of: 4.52 (.78). These results looked more impressive. However, the key variable to consider is the effect size difference between the SI rating and the pre-II of students. An effect size difference larger than .20 was operationally defined as the kind of minimal difference between incoming interest and environmental interestingness that we would want to detect in a high SI environment. Based on the results in Table 1, the SI-PreII effect size difference for the high school and graduate environments were .48 and .56 respectively. These numbers indicate that both environments were high SI environments. Thus a look at Table 1 will reveal that for the high school environment, even though an SI mean of 3.75 is not impressive, it was noticeably larger than the mean individual interest of the students at the start of the curriculum.

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. Intuitively one would expect that pre-II would be the most high correlated variable with post-II. However, 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. Table 2 shows the results of the MRA analysis done for the high school and doctoral environments. The table also shows the MRA done for the complete sample of 598 students in a variety of different mathematics class. Both indicate the "value-added" aspect of SI since it accounts for an additional 15-17% of the post-II variance (in all cases the F-test for the $R^2_{increase}$ was significant for SI). Thus it appears that SI helps explain an important additional amount of the variance in post-II scores.

Insert Table 2 about here

The third research question addresses the heart of the issue: will a high SI environment substantially increase II? The figures presented in Table 1 indicate "yes." The effect size changes in II for the high school and graduate environments were .48 and .64 respectively. These are positive and moderate effect size measures.

The fourth research question asked whether high SI environments will substantial decrease anxiety. The figures in Table 1 are ambiguous to this question. The effect size change in anxiety for the high school and graduate environments was -.40 and -.25 respectively. However, only the change at the high school level was statistically significant. These are negative (indicating decreases) and small-to-moderate effect size changes.

The fifth research question looks at if there are gender differences with regards to previous questions. Table 3 (below) shows the gender breakdown of responses in the two environments. For the high school <u>Statistical Thinking</u> environment, the results were somewhat surprising. In general the results were more impressive for females than males. Females experienced a larger effect size change than males in terms of II (.72 to .22), there was a much larger SI-PreII effect size difference (1.09 to .09), and very little difference in terms of changes in anxiety (-.36 to -.45, neither being statistically significant). In the graduate level setting, the results were somewhat surprising but with a different pattern of results. Males experienced a larger effect size change than females in terms of II (1.00 to .60), there was a smaller SI-PreII effect size difference (.36 to .61), and a greater effect size difference in terms of anxiety (-.51 to -.16). Please note that in Table 3 only the graduate males' change in II was statistically significant.

Insert Table 3 about here

The sixth research question looks at whether high SI environments are particularly beneficial for students with a low pre-II score. In other words, are highly interesting environments specifically helpful for students who have little previous interest in mathematics? Operationally a student was defined as having a low pre-II if their mean score on the scale was 3.0 or lower (the midpoint of the scale is 3.5). This resulted in 11 of the 26 students in the high school environment being identified as low II students and 8 out of the 44 students in the graduate environment being identified as low II students. Table 4 presents the results from the low II students in both environments. The SI-PreII differences in effect size terms for the high school and graduate environments were 1.18 and 2.20 respectively. Clearly the low-II students were perceiving large differences between their incoming II and the interestingness of the environments in which they were now learning. The II difference between pre and post measurements in effect size terms was 1.09 for the high school students and 1.36 for the graduate students. Again we notice large effect size changes. Finally the anxiety difference between the two measurement times in effect size terms was -.77 for the high school students and -.36 for the graduate students. The effect size change in anxiety for graduate students was not statistically significant. Though not as large as before, the changes in anxiety were quite striking for the high school students. The sum total of these results indicate that high SI environments appear to be *especially* beneficial to students with low pre-II scores.

Insert Table 4 about here

SUMMARY AND CONCLUSION

So what's the big deal? Highly interesting environments result in increased individual interest on the part of students. 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, (2) the power of environments, and (3) the central role well-designed statistics courses may have on students' future decisions.

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 changed individual interests, 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 approximately half a standard deviation (recall the effect size change in II of .48 and .64 in the two statistical learning environments). 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 unchangeability of individual interest. In addition, the results generally support the model of situational interest presented in Figure 2.

The results from this study are essentially optimistic. In short, they indicate that learning environments 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. Although not presented in this paper, a more complete analysis of the complete sample of 598 students from Grade 5 through doctoral level mathematics classes indicates that 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 the previous motivational attitudes students bring with them into the classroom.

Probably most central to this study, however, is the central role well-designed statistics 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 statistics 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. Well-designed statistics courses, at the secondary level, offer a reasonable way to implement a "meaningful" mathematics curriculum. Statistical understanding lends itself very naturally to learners making meaningful connections with the world around them. While the particular high school statistics curriculum used in this study was beneficial (in motivational terms), the author further suggests that other reasonably designed statistics courses at the secondary level may be an effective way to develop involving and meaningful mathematical understanding. Moreover, the nature of such 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.

A focus group session was conducted with seven females from the high school Statistical Thinking course in the last week of the curriculum. All seven had been previous low achievers in mathematics, but were now achieving at a good to excellent level. The central purpose of the focus group was to get an initial handle on why this type of curriculum seemed to work for them. Two themes emerged from the session. First, they all agreed that the bane of mathematics students are *word problems*. They perceived that the challenge to create *teaching sheets* was an opportunity for them to create their own word problems. This factor was important to them because: (1) they did not write *teaching sheets* that tried to "trick" other people and (2) they created storylines for their *teaching sheets* which were connected with their everyday concerns. In other words, they were able to make meaningful connections between the statistical concept being learned and their lives. The second theme was that the spreadsheet software program used helped them to think mathematically. They knew they had to learn how to use the spreadsheet program effectively, but an unintended consequence is they found that their new spreadsheet skills helped them to organize their thinking with regards to solving statistical problems. These qualitative findings provide additional support for the thinking that motivational effectiveness is tied-in to learning environments which allow students to create/find meaning in the mathematics and allow them to be active learners of mathematical concepts.

The implications of motivationally-effective statistics classrooms at the graduate level is just as important. In many graduate programs we want students to learn to be skilled researchers. Generally this implies students having a reasonable grasp of both quantitative and qualitative methods. Yet if graduate students have bad experiences (motivationally speaking) in their statistics courses, then it is reasonable to expect a noticeable percentage of such students to say

"No" to statistics by focusing on qualitative methods only. In short, graduate students (like high school students) have important decisions to make in their careers. Yet it may be that all too often these decisions are more influenced by their motivational experiences rather than a rational analysis of what skills they need to develop. The result, at both levels of education, is that students may elect to avoid future learning which involves mathematics in general and statistics in specific.

If a significant number of students actually find mathematics or statistics 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 statistics, and to provide more meaningful and involving learning experiences. While there are likely many other effective ways to enhance students' motivation beyond the two classroom environments used in this study, it does behoove us to have a better understanding of what makes effective statistics classrooms "tick" and to learn from the successful experiments that are *already* being implemented in schools and colleges.

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Figure 1. Model of the Interest Construct

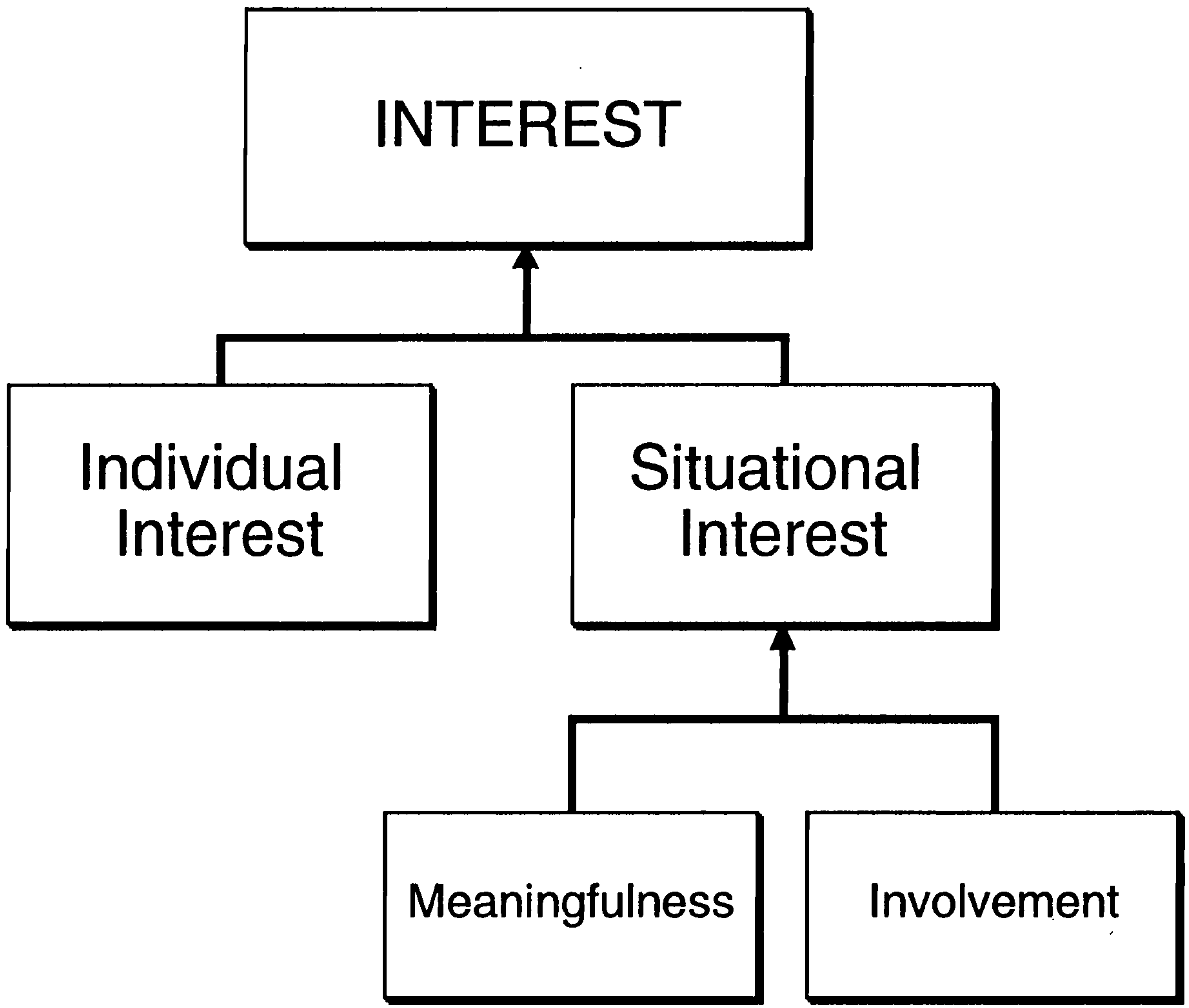


Figure 2. A Model of Situational Interest for Mathematics

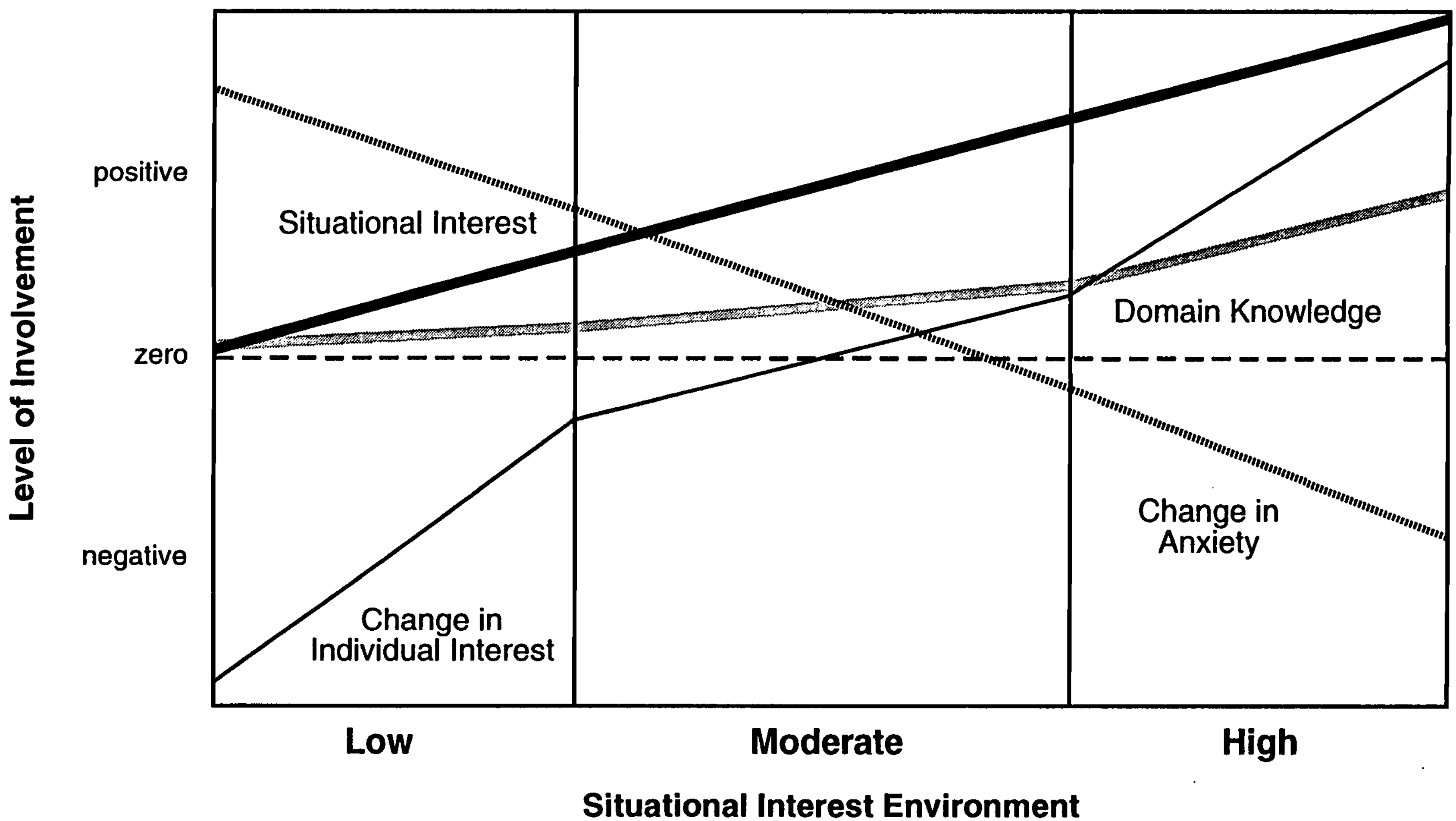
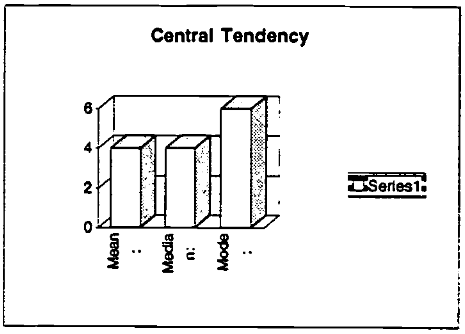


Figure 3. Example student teaching sheet.

Teaching Sheet Central Tendency
Last Bronze Skill, Assignment #16
By: Fatima Brenes

My cousin, Luis is a candy hungry kid. He loves going to piñata's party, to get all the candy he can get. He does not want to the person who breaks the piñata because usually that person has a blind fold on, and hardly gets any candy. He wants to know if either he should be in front or behind the person who brakes the piñata, so he can get candy. So everytime he went to the parties he keep track on what number in line the person was who broke the piñata everytime. What usually happens when Luis goes to piñata's parties.

Names	Number in Line
Mica	6
Jesus	4
Tony	2
Alejando	6
Alejandra	1
Alex	2
John	5
Oscar	3
Josh	4
Joey	7



Sum:	40
Count:	10
Mean:	4
Median:	4
Mode:	6

Now change the numbers around to see the graph change and enjoy the Central Tendency playground!!! **Which Central Tendency would be the best the most accurate? Where should Luis be in line?**

First the **Mean, Medaian,** and **Mode**, are called "Central Tendency." First the **mean** is the average of all the numbers. To get the **mean** first you have all up all your numbers and divide them by the nunber of people you have. Try to make the **mean** be 4.

Second is the **median**. The **median** is the number that is in the middle between your highest number and your lowest number. Try to make the **median** be 10.

The thrid and last Central Tendency is called the **mode**. The **mode** is what number happens more than once. In this the **mode** is 5, but should also be 6 because 5 and 6 happens more than once. The computer is able to pick up one number. Try making the **mode** be 7.

THIS PICTURE IS OF THE PINTA THAT THEY BROKE AT EACH AND EVERY PARTY, IT WAS FULL OF CANDY AND MONEY FOR ALL THE LITTLE KIDS LIKE LUIS.

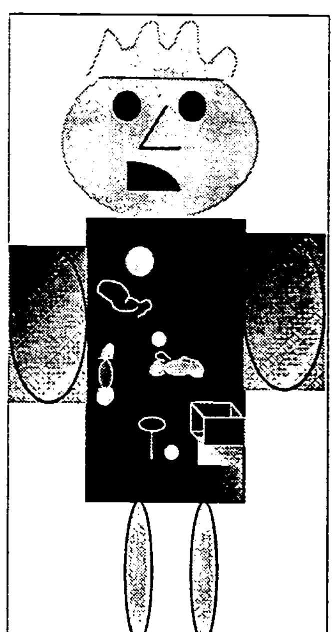


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Table 1. Descriptive Results.

Statistical Thinking High School Environment

Variable	Mean	S.D.	N = 26	
SI	3.75	1.16		
Pre II	3.18	1.06		
Post II	3.60	1.01		
Pre Anxiety	4.17	1.18		
Post Anxiety	3.61	1.17		
Difference Variables			Δ	p
SI-Pre II Diff	0.57	1.18	0.48	0.02
II Diff	0.42	0.88	0.48	0.02
Anx Diff	-0.56	1.39	-0.40	0.049

Graduate Educational Statistics Environment

Variable	Mean	S.D.	N = 44	
SI	4.52	0.78		
Pre II	3.92	1.08		
Post II	4.41	0.85		
Pre Anxiety	3.85	1.05		
Post Anxiety	3.63	1.15		
Difference Variables			Δ	p
SI-Pre II Diff	0.60	1.08	0.56	0.00
II Diff	0.49	0.77	0.64	0.00
Anx Diff	-0.22	0.88	-0.25	ns

Table 2. Multiple Regression Analysis.

DV=Post PI

TOTAL	Total R^2	R^2 Increase	B	Zero r
Pre PI	0.54		0.42	0.73
Anx Diff	0.57	0.03	-0.07	-0.13
SI	0.78	0.21	0.57	0.80

N = 598

High School	Total R^2	R^2 Increase	Beta	Zero r
Pre PI	0.41		0.54	0.64
Anx Diff	0.59	0.18	-0.33	-0.22
SI	0.74	0.15	0.44	0.72

N = 26

Graduate Education	Total R^2	R^2 Increase	Beta	Zero r
Pre PI	0.50		0.54	0.71
Anx Diff	0.50	0.00	0.02	0.07
SI	0.68	0.17	0.45	0.64

N = 44

Table 3. Gender Analysis.

Statistical Thinking High School Environment

Females N = 15

Variable	Mean	S.D.	Δ	p
SI	3.97	1.06		
Pre II	3.08	0.86		
Post II	3.65	1.00		
Pre Anxiety	4.37	1.19		
Post Anxiety	3.85	1.01		
Difference Variables				
SI-Pre II Diff	0.8900	0.82	1.09	0.00
II Diff	0.57	0.79	0.72	0.02
Anx Diff	-0.52	1.43	-0.36	ns

Males N = 11

Variable	Mean	S.D.	Δ	p
SI	3.44	1.28		
Pre II	3.30	1.31		
Post II	3.52	1.06		
Pre Anxiety	3.91	1.17		
Post Anxiety	3.28	1.33		
Difference Variables				
SI-Pre II Diff	0.14	1.48	0.09	ns
II Diff	0.22	0.99	0.22	ns
Anx Diff	-0.63	1.40	-0.45	ns

Graduate Educational Statistics Environment

Females N = 32

Variable	Mean	S.D.	Δ	p
SI	4.59	0.77		
Pre II	3.88	1.17		
Post II	4.40	0.91		
Pre Anxiety	3.94	0.97		
Post Anxiety	3.80	1.19		
Difference Variables				
SI-Pre II Diff	0.71	1.17	0.61	0.00
II Diff	0.52	0.87	0.60	0.00
Anx Diff	-0.14	0.89	-0.16	ns

Males N = 12

Variable	Mean	S.D.	Δ	p
SI	4.31	0.79		
Pre II	4.04	0.83		
Post II	4.46	0.72		
Pre Anxiety	3.60	1.24		
Post Anxiety	3.17	0.92		
Difference Variables				
SI-Pre II Diff	0.27	0.76	0.36	ns
II Diff	0.42	0.42	1.00	0.01
Anx Diff	-0.43	0.85	-0.51	ns

Table 4. Low Pre II Student Analysis.

Statistical Thinking High School Environment

N = 11

Variable	Mean	S.D.	Δ	p
SI	3.34	1.21		
Pre II	2.23	0.66		
Post II	3.09	0.90		
Pre Anxiety	4.89	1.10		
Post Anxiety	3.80	1.27		
Difference Variables				
SI-Pre II Diff	1.11	0.94	1.18	0.00
II Diff	0.86	0.79	1.09	0.01
Anx Diff	-1.09	1.41	-0.77	0.03

Graduate Educational Statistics Environment

N = 8

Variable	Mean	S.D.	Δ	p
SI	4.22	0.99		
Pre II	2.13	0.57		
Post II	3.59	1.22		
Pre Anxiety	4.78	0.16		
Post Anxiety	4.38	1.15		
Difference Variables				
SI-Pre II Diff	2.09	0.95	2.20	0.00
II Diff	1.46	1.07	1.36	0.01
Anx Diff	-0.40	1.11	-0.36	ns

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