A Cross-Cultural Study of the Connection Between Students' Attitudes Toward Statistics and the Use of Constructivist Strategies in the Course

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Key Words: Anxiety; Attitude Toward Statistics scale; Constructivist Learning Environment Survey; Non-cognitive factors.

Abstract

This study investigated the relationship between a constructivist learning environment and students' attitudes toward statistics. The Constructivist Learning Environment Survey (CLES) and the Attitude Toward Statistics scale (ATS) were used to measure the environment and attitudes respectively. Participants were undergraduate students of an introductory college statistics course. They were drawn from Seattle Pacific University in the US and the University of Zimbabwe.

The study had two components. One component addressed hypotheses examining potential differences between groups and the other explored relationships between variables. The environment was not manipulated and the data was collected from courses that already existed in the form studied. For this reason, the overall design of the study had causal comparative and correlational elements. A constructivist learning environment was found to be significantly related to students' attitude toward statistics. Furthermore, there were significant differences between the groups based on location.

The study examined the similarities and differences in perceptions and attitudes of students from two very different learning milieus. Cross-cultural comparisons have the potential to generate new insights into statistical pedagogy and the role noncognitive socio cultural variables play in teaching statistics to college-age students.

1. Introduction
Although statistical knowledge is vital as a research tool, several studies (see, for example, Roberts and Bilderback 1980; Roberts and Saxe 1982; Benson 1989) have shown that many college students are anxious about taking a statistics course. There has been little research on how to address such anxiety despite the fact that it is related to student failure to achieve. Dillon (1982) found, for example, that anxious students tend to find the course more difficult than it should be and instructional goals more difficult to achieve. This generally leads to an aversion to statistics and a negative attitude toward related sciences, such as psychometry, sociometry, biometry and econometrics (Sutarso 1992b). As Gal, Ginsburg, and Schau (1997) stressed, students' attitudes and beliefs play a major role in the students' success or failure in statistics. Teachers, therefore, need to focus on more than transmitting knowledge and skills. Reform in college-level statistics education has focused on non-cognitive aspects of instruction to include attitudes, beliefs, interests, expectations and motivation (Gal and Ginsburg 1994; Garfield 1994).

Anxiety appears to be related to statistics achievement (Onwuegbuzie 2000a, 2000b; Tremblay, Gardner and Heipel 2000), however the nature of the relationship is not clear. Anxiety about the course at the beginning seems to have no relation to the end result in terms of achievement, but anxiety about a particular test seems to have a strong negative relationship to achievement on the test (Harvey, Plake, and Wise 1985). Roberts and Saxe (1982) found that students with positive attitudes toward statistics generally had better statistics achievement. Harvey et al. (1985) found that while attitude toward the course, measured at the beginning of the semester, was significantly related to performance, attitude toward the field, generally, was not related to performance. This suggests that a supportive atmosphere can help achievement in the course, regardless of attitude toward the field of statistics.

How does the instructional environment affect learning? The strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of their classroom environments. Fraser (1998) tabulated a set of 40 studies in which the effects of classroom environment on students' outcomes in science were investigated. The tabulation showed that studies of association between outcome measures and perceptions of classroom environment have involved a variety of cognitive and affective outcome measures, a variety of classroom environment instruments, and a variety of samples (ranging across a number of countries and grade levels).

From the review of studies on the relationship between the learning environment and attitude or achievement, it can be concluded that the environment is an important factor in learning (Haertel, Walberg, and Haertel 1981; Fraser and Fisher 1982; Wong and Fraser 1994; Fraser 1998; Riah and Fraser 1998). Different kinds of environments were studied. This raises the question of whether there is a particular environment that is more effective than the others.

In math and science education a constructivist learning environment has been espoused as an effective environment for student learning (Fraser and Walberg 1995; Duit, Fraser, and Tregast 1996). A constructivist learning environment is defined as a place where learners are able to work together and support each other as they use a variety of tools to pursue learning and engage in problem solving activities (Neo and Neo 2002). This environment, based on the constructivist learning philosophy, has its foundations in cognitive learning psychology. It is rooted mainly in the works of Dewey (1916), Piaget (1955) and Vygotsky (1978). The premise of this model is that knowledge is constructed by an individual based on his or her prior experience rather than processed from information received from an external source. Constructivist learning places emphasis on learning as a social and collaboration process as well as problem solving of realistic and authentic tasks.

Research in the area of statistics education has identified attitude and learning environment as two of the most salient issues needing to be further researched. The constructivist view has become one of the
leading theoretical positions in education and has become a most powerful driving force in science and mathematics education, particularly during the past decade (Fraser and Walberg 1995; Draper 2002). There is a belief that "if constructivism can take root in these disciplines it can succeed anywhere" (Phillips 2000, p. 5).

2. Research Aims and Questions

The study examined the relationship between a constructivist learning environment and students' attitudes toward statistics, and whether this relationship differs depending on classroom location. After a review of known determinants of children's performance, Walberg (1979) found that aptitude and the learning environment during instruction explained most of the variance in performance. Since the research shows that attitude and achievement are related (Roberts and Saxe 1982; Harvey et al. 1985; Sutarso 1992a; Zimmer and Fuller 1996), constructivism may be a way to influence achievement. A constructivist learning environment may be even more important if it can be shown to have an impact on both the cognitive and non-cognitive dimensions of learning.

Where previous research has investigated attitudes in statistics and classroom environments separately, the current study explores cross-culturally the relationship of constructivist factors and attitude simultaneously in statistics classrooms. Furthermore, studies on constructivist environment have been largely conducted in the subject areas of math and science and not statistics specifically (see, for example, Cannon 1997; Corley 1997; Fisher and Kim 1999). These studies have largely investigated undergraduates, elementary school teachers, and high school students in Western countries rather than in developing nations.

The hypotheses to be tested by the study were:

1. Perceptions of the environment will not differ significantly between groups of students in Zimbabwean and American statistics classrooms.

2. There will be no significant difference in attitudes toward statistics between students in Zimbabwean and American classrooms.

3. There will be no significant difference in the Classroom Learning Environment Survey's (CLES) five factors correlations with college students' attitude toward statistics.

4. There is no significant correlation between congruency in perceptions of classroom environment and attitude toward statistics.

3. Method

3.1. Participants

The criterion for the selection of the participants was that they be undergraduate students of statistics in an introductory level course. The United States sample was drawn from statistics students in various departments at Seattle Pacific University. A total of 109 students were sampled. Of those, 95 were used in the data analysis. The others were disregarded due to incomplete questionnaires. There were 69 females and 26 males in the sample.

Overall, the average age of the participants was 20.5 years old. Most of the students (89.5%) had not taken a college statistics course prior to the current one. Less than 10% (9.5%) of the students had had
one previous college level statistics course. About 37% of the participants had previously taken no math classes, while 37.4% participants had taken one math class prior to the current class, and 21.1% had previously taken two math classes. A small percentage of the participants (4.4%) had taken more than two math classes prior to the current class. The vast majority (91.6%) of the students were taking the current class because it was a requirement for their programs of study.

The Zimbabwean sample was similarly selected. The students were drawn from the Business, Accounting and Economics departments. Of the 190 subjects sampled, the responses of 120 were used in the data analysis. There were 34 female students and 86 male students included in the sample. The average age for this sample was 20.9 years. About 73% of these students reported taking no statistics courses prior to the current one, 20% reported taking one, and 7.5% reported taking more than one statistics class. For the majority of the students (96.7%), the statistics course was a requirement of the degree program. Twenty percent of the participants had previously taken no math classes, whereas 43.3% participants had taken one math class prior to the current class, and 27.5% had previously taken three math classes. A smaller percentage of the participants (9.1%) had taken more than three math classes prior to the current class.

3.2. Design

The study had two components. One component addressed hypotheses examining potential differences between groups and the other explored relationships among variables. The overall design of the study was causal comparative with correlational elements.

The purpose of causal comparative research is to identify possible cause-and-effect relationships. Ideally researchers search for actual cause-and-effect relationships. An experimental design would be a more rigorous approach to establishing cause-and-effect. However in the present study, the environment was not manipulated and the data was collected from courses that already existed in the form studied so that a causal-comparative design was selected. The correlational design was used for questions that investigated the relationships between perceptions of the environment and attitudes.

3.3. Instrumentation

The two instruments (CLES and ATS) used to collect data for the study were evaluated for validity and reliability. A principal component factor analysis (PCA) with varimax rotation was conducted. Tests of internal consistency were also conducted on the components identified by the PCA varimax rotation using Cronbach's alphas and item-total correlations.

The CLES (Taylor, Fraser, and Fisher 1996) was used to measure the students' perceptions of their learning environment. The CLES is designed to allow teachers and researchers to monitor the development of constructivist approaches to teaching school science and mathematics. It was specifically created for junior-high to high school science and math students in western cultures. The CLES has 25 items evenly divided into 5 sub-scales; personal relevance, uncertainty, critical voice, shared control and student negotiation. It also has two forms; the "actual" form and the "preferred" form. The "preferred" form measures what one wishes the learning environment to be (for example, "In this class I wish I could learn how statistics can be part of my out-of-school life."), while the "actual" form measures one's perceptions of the current learning environment (for example, "In this class I learn how statistics can be part of my out-of-school life."). A higher score on the "actual" form indicates that the respondent perceives the learning environment as relatively more constructivist. A higher score of the "preferred" form suggests that the respondent has a greater preference for a constructivist learning environment. A smaller difference between the two scores indicates a closer fit between the environment and the respondent's preference, that is, greater congruence between the "actual" and "preferred" environment. Congruence in this study is defined as the match between the "actual" and the "preferred" learning
environment. Research suggests that actual-preferred congruence is an important factor in predicting students' achievement of affective and cognitive aims (Fraser and Fisher 1982; Aldridge, Fraser, and Huang 1999).

The students' attitudes were measured using the Attitude Toward Statistics scale (ATS; Wise 1985). The primary purpose of the ATS is to investigate college students' attitudes toward introductory courses in statistics. The ATS has two domains: (a) attitude toward the course students are enrolled in (Course), and (b) attitude toward the use of statistics in their field of study (Field). The scale has 29 items with 20 in the Field subscale and 9 in the Course subscale. Students are asked to answer the items on a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree". A higher score on the ATS indicates a more positive attitude toward statistics.

There were some questions on the reliability of the instruments for use with the Zimbabwean group. The impact of these reliability issues is greatly reduced when working with sample sizes greater than 50 (Kline 1994). In the case of the Zimbabwean group, the sample size appeared to be large enough (n = 120) to counter balance the effect of inadequate reliability. The "actual" form of the CLES had acceptable reliability and the factor structures for the two groups were better matched. The "preferred" form of the CLES and the ATS should be used with caution. Given that the current study is for research rather than diagnostic purposes, the instruments are assumed to be appropriate for cross-cultural comparisons.

3.4. Procedures

The students were measured in their classrooms a few weeks after classes began to allow the students some time to be familiar with the course and the instructor. The data was collected from January 2001 to March 2001. All students were informed about the nature of the study and what was required of them. Students were also informed that participation was voluntary and they were assured that their responses would be treated with confidentiality. The data was collected using questionnaires administered during regular class time.

First, students were asked to provide their background information. The CLES was then administered, which has two forms, the "actual" and the "preferred" forms. Finally, the participants completed the Attitude Toward Statistics scale. The total time taken to complete the questionnaires was between 15 and 20 minutes. During that time the researcher remained in the classroom and collected the questionnaires as they were completed. Besides ensuring a higher return rate, this gave the students an opportunity to ask for clarification on any questions that they found confusing.

Instructions on the completing of the CLES had to be carefully explained. The survey has two forms that have very similar questions (for example, "In this class I wish that I would get a better understanding of the world outside of school." and "In this class I get a better understanding of the world outside of school."). It was important for the participants to understand that the "preferred" form measured what they wished the learning environment to be, while the "actual" form measured their perceptions of the current learning environment. Without careful explanation there was a possibility that the participants would view the forms as duplicates and thus fail to complete one of them.

4. Results

4.1. Hypothesis 1

Hypothesis 1 investigated potential differences in perceptions of the environment between Zimbabwean students and American students in statistics classrooms. The means scores and standard deviations for the
two forms of the CLES and congruence are shown by location in Table 1.

Table 1. Descriptive statistics for the US and Zimbabwean samples.

| CLES          | Preferred | Actual | Congruence |
|---------------|-----------|--------|------------|
|               | Zimbabwe  | United States | Zimbabwe  | United States | Zimbabwe  | United States |
| *n*           | 120       | 95     | 120        | 95          | 120        | 95          |
| Personal Relevance | *M* = 3.75, *SD* = 0.57 | *M* = 3.50, *SD* = 0.99 | *M* = 3.11, *SD* = 0.94 | *M* = 2.96, *SD* = 0.92 | *M* = 0.75, *SD* = 0.82 | *M* = 0.96, *SD* = 0.83 |
| Uncertainty   | *M* = 3.00, *SD* = 0.83 | *M* = 2.62, *SD* = 0.80 | *M* = 2.56, *SD* = 0.96 | *M* = 2.22, *SD* = 0.81 | *M* = 0.57, *SD* = 0.65 | *M* = 0.76, *SD* = 0.64 |
| Critical voice| *M* = 3.62, *SD* = 0.80 | *M* = 3.40, *SD* = 1.24 | *M* = 3.34, *SD* = 0.87 | *M* = 3.64, *SD* = 1.20 | *M* = 0.58, *SD* = 0.78 | *M* = 1.21, *SD* = 1.26 |
| Shared control| *M* = 2.67, *SD* = 0.83 | *M* = 3.10, *SD* = 0.97 | *M* = 2.06, *SD* = 1.00 | *M* = 2.10, *SD* = 1.02 | *M* = 0.75, *SD* = 0.86 | *M* = 1.33, *SD* = 1.05 |
| Student negotiation | *M* = 3.98, *SD* = 0.67 | *M* = 3.42, *SD* = 1.01 | *M* = 3.71, *SD* = 0.82 | *M* = 2.95, *SD* = 1.09 | *M* = 0.51, *SD* = 0.69 | *M* = 1.06, *SD* = 1.06 |

The results for hypothesis 1 are shown in Table 2. A significant overall *F* was found for location, (Wilks' *Λ* = 0.78, *F*(1,215) = 12.04, *p* < 0.00, *η²* = 0.22). Follow-up univariate ANOVAs were computed on mean total and subscale scores. The Zimbabwean sample was found to have a significantly greater preference for uncertainty (*F* = 11.06, *p* < 0.01, partial *η²* = 0.05) and for student negotiation (*F* = 23.40, *p* < 0.01, partial *η²* = 0.10) than the American participants (Table 1). However the American students had a significantly greater preference than the Zimbabwean participants on the shared control subscale (*F* = 11.78, *p* < 0.01, partial *η²* = 0.05).

For the "actual" environment the overall *F* was found to be significant, (Wilks' *Λ* = 0.77, *F* = 12.64, *p* < 0.00, *η²* = 0.23). Follow-up ANOVAs indicated that Zimbabwean students perceived their learning environment as more constructivist in the areas of uncertainty and student negotiation (main effect location *F*(1,215) = 7.91, *p* < 0.01, partial *η²* = 0.04). The Zimbabwean sample also scored significantly higher than the American group on the student negotiation variable (main effect location *F*(1,215) = 34.37, *p* < 0.01, partial *η²* = 0.14).

Table 2. Effects of location on students' perception of the environment.
When person-environment fit (as measured by congruence between the "actual" and the "preferred" environments) was examined a significant overall $F$ was found, (Wilks' $\Lambda = 0.84$, $F = 7.89$, $p < 0.00$, $\eta^2 = 0.16$). Follow-up ANOVAs employing the Bonferroni method showed that Zimbabwean students exhibited a greater person-environment fit than the American students. The total mean congruence score for the Zimbabwean students was significantly lower than that of their American counterparts on critical voice (main effect for location $F(1, 215) = 20.05$, $p < 0.01$, partial $\eta^2 = 0.09$) subscales.

### 4.2. Hypothesis 2

Hypothesis 2 examined potential differences in attitude toward statistics between Zimbabwean students and American students. The mean score and standard deviation on the ATS scale are shown in Table 3.

#### Table 3. Descriptive statistics for the US and Zimbabwean samples.

| ATSP | Zimbabwe | United States |
|------|----------|---------------|
| $n$  | 120      | 95            |
| Course | $M$ | 34.9 | 28.9 |
|       | $SD$  | 6.04 | 8.0  |
| Field | $M$  | 79.5 | 74.0 |
|       | $SD$  | 8.9  | 13.1 |
| Total | $M$  | 114.4| 103.0 |
|       | $SD$  | 13.5 | 18.8 |

The results for Hypothesis 2 are shown in Table 4. A significant overall $F$ was found for location, (Wilks' $\Lambda = 0.85$, $F(1, 215) = 19.28$, $p < 0.00$, $\eta^2 = 0.15$). Zimbabwean students were found to have a more positive attitude toward statistics. The total mean score for the Zimbabwean group was significantly
higher than that of the American group ($F = 27.01, p < 0.01, \eta^2 = 0.11$).

### Table 4. Effects of location on students' attitudes toward statistics.

|          | ATS   |
|----------|-------|
|          | $F$   | $p$ | $\eta^2$ |
| Course   | 22.55 | 0.00 | 0.10    |
| Field    | 15.37 | 0.00 | 0.07    |
| Total    | 22.22 | 0.00 | 0.10    |

### 4.3. Hypothesis 3

Hypothesis 3 explored the relationship between the learning environment and attitudes toward statistics. A multiple regression analysis was conducted to identify the constructivist factors that had the closest association with students' attitude toward statistics, and also to select the best set of predictors of attitude. The five subscales of the CLES "actual" form were used as the predictor variables and the total attitude score was the criterion variable.

When the two samples were combined, personal relevance and student negotiation were identified as the best predictors of students' attitude toward statistics, as shown in Table 5 ($R = 0.35, p < 0.01$). Although the correlation was significant the two variables only accounted for 12% of the variance in students' attitudes toward statistics.

### Table 5. Summary of stepwise multiple regression analysis (combined samples).

|                              | $B$  | $\beta$ | $R$  | $R^2$ | $F$  | $p$  |
|------------------------------|------|---------|------|-------|------|------|
| Personal relevance Student negotiation | 5.05 | 2.69    | 0.28 | 0.16  | 0.35 | 0.00 |
| Criterion variable: attitude |      |         |      |       |      |      |

A correlation analysis (Table 6) showed that personal relevance and student negotiation were both significantly related to students' attitude toward the course ($r = 0.16, p < 0.05$ and $r = 0.25, p < 0.01$ respectively). With regards to students' attitude toward the field of statistics, personal relevance ($r = 0.36, p < 0.01$), uncertainty ($r = 0.21, p < 0.01$), critical voice ($r = 0.23, p < 0.01$) and student negotiation ($r = 0.16, p < 0.05$) subscales were all significantly related to the "field" subscale. These four subscales were also significantly related to the total attitude toward statistics (personal relevance ($r = 0.31, p < 0.01$), uncertainty ($r = 0.19, p < 0.01$), critical voice ($r = 0.19, p < 0.01$) and student negotiation ($r = 0.22, p < 0.01$)). Although the results were significant, the magnitudes of the correlation coefficients indicate...
relatively weak relationships. The percentage of variance accounted for ranged from about 3% to about 13%, as the values of \( r^2 \) would indicate.

### Table 6. Correlations between the CLES scales and the ATS scales.

| CLES          | Combined Samples | Zimbabwe | United States |
|---------------|------------------|----------|---------------|
| "actual" form scales |                  |          |               |
| Personal relevance | 0.16* | 0.36** | 0.31** | 0.04 | 0.26** | 0.19* | 0.24* | 0.45** | 0.41** |
| Uncertainty    | 0.11             | 0.21** | 0.19** | 0.11 | 0.19* | 0.17  | -0.02 | 0.16  | 0.36** |
| Critical voice | 0.09             | 0.23** | 0.19** | 0.12 | 0.14  | 0.15  | 0.19  | 0.36** |
| Shared control | 0.05             | 0.12   | 0.11   | 0.06 | 0.06  | 0.07  | 0.08  | 0.20  | 0.17  |
| Student negotiation | 0.25** | 0.16*  | 0.22** | 0.25** | 0.22* | 0.26** | 0.03  | -0.01 | 0.01  |

* *p < 0.05, **p < 0.01

When the Zimbabwean sample was examined separately (Table 7), student negotiation was identified as the most important CLES subscale in predicting students' attitude toward statistics \((R = 0.26, p < 0.05)\). There was a significant correlation coefficient for CLES's personal relevance subscale and "field" \((r = 0.26, p < 0.01)\), and for personal relevance and total attitude \((r = 0.19, p < 0.05)\). Uncertainty was significantly related to attitude toward the field of statistics \((r = 0.19, p < 0.05)\). Furthermore, there was a significant correlation coefficient between student negotiation and "course" \((r = 0.25, p < 0.01)\), "field" \((r = 0.22, p < 0.01)\), and total attitude \((r = 0.26, p < 0.01)\).

### Table 7. Summary of stepwise multiple regression analysis (Zimbabwean sample).

|          | B     | \( \hat{\beta} \) | R    | \( R^2 \) | F     | p     |
|----------|-------|-------------------|------|-----------|-------|-------|
| Student negotiation | 4.21  | 0.26              | 0.26 | 0.07      | 8.18  | 0.01  |

Criterion variable: attitude

When the US sample was examined separately (Table 8), personal relevance was identified as the most important CLES factor in predicting students' attitude toward statistics \((R = 0.41, p < 0.01)\). A correlation analysis showed that the personal relevance and critical voice variables were significantly associated with attitudes toward statistics. There was a significant correlation coefficient between personal relevance and "course" \((r = 0.24, p < 0.05)\), between personal relevance and "field" \((r = 0.45, p < 0.01)\), and between personal relevance and total attitude \((r = 0.41, p < 0.01)\). In addition, there was a significant correlation
coefficient for the critical voice subscale and "field" \((r = 0.36, p < 0.01)\) and critical voice and total attitude \((r = 0.34, p < 0.01)\).

**Table 8.** Summary of stepwise multiple regression analysis (US sample).

|                | B   | \(\beta\) | \(R\) | \(R^2\) | \(F\) | \(p\) |
|----------------|-----|------------|-------|---------|-------|-------|
| Personal relevance | 8.48 | 0.41       | 0.41  | 0.17    | 19.26 | 0.00  |

Criterion variable: attitude

### 4.4. Hypothesis 4

Hypothesis 4 examined the relationship between person-environment fit and attitude toward statistics. **Table 9** shows the results of this examination. The person-environment fit was found to be significantly related to students' attitude toward statistics. The correlation between attitude and congruence in personal relevance was significant \((r = -0.18, p < 0.01)\), as was the correlation between attitude and congruence in critical voice \((r = -0.18, p < 0.01)\). Furthermore, the correlation between attitude and congruence in shared control was significant \((r = -0.32, p < 0.01)\), as well as between attitude and congruence in student negotiation \((r = -0.17, p < 0.05)\). The relationship between attitude and congruence in uncertainty was nonsignificant \((r = -0.05, p > 0.05)\). Since a smaller value in person-environment fit indicates a closer fit, a negative correlation in this examination indicates that the closer the person-environment fit the more positive the attitude toward statistics.

When taken together, congruence in all five CLES subscales was found to be significantly associated with attitude toward statistics. \((R = 0.39, p < 0.01)\). The five factors together explained 15.1% of the variance in students' attitude.

A multiple regression analysis using the stepwise method identified congruence in shared control and in uncertainty as the two most important factors in predicting a student's attitude toward statistics \((R = 0.36, p < 0.01)\). These two variables taken together explained 13% of the variance in students' attitude.

**Table 9.** Pearson correlations of person-environment fit with attitude.

| Congruence in the CLES scales | Attitude |
|-------------------------------|----------|
| Personal relevance            | -0.18**  |
| Uncertainty                   | 0.05     |
| Critical voice                | -0.18**  |
| Shared control                | -0.32**  |
| Student negotiation           | -0.17*   |

*\(p < 0.05\), **\(p < 0.01\)*
5. Discussion

The CLES is based on constructivist theory. A higher score indicates a relatively more constructivist learning environment (Taylor et al. 1996). Since the mean score for the Zimbabwean students was found to be greater than that of American students on the preferred form, it would imply that the Zimbabwean students had a relatively greater preference for a constructivist learning environment. The effect was most pronounced on the student negotiation variable.

The difference in preference for shared control may stem from a cultural difference. Generally, the US culture promotes independence and individual rights more than the Zimbabwean culture. Zimbabweans are more accepting of direction from those in authority (Matunda 1995; Ojimba 1995). This may explain why students in the US sample showed a greater preference to be consulted and to be involved in controlling the learning environment. The two samples however had relatively equal means on the critical voice scale. This suggests that while it may appear that the two groups have different preferences, they both want to be heard. Moreover, although some differences were statistically significant, the subscales only explained 17% of the difference as indicated by the eta squared value. Nonetheless, Zimbabwean students consistently preferred a more constructivist learning environment than American students.

Dewey (1916) posited that students' own internal motivation can provide the initiative for long-term successful learning efforts. What instructors need are effective techniques for helping students harness their own vitality, energy, and curiosity in the difficult task of learning. While constructivist approaches may be valuable in this respect, they are not necessarily the only way to teach statistics. Constructivism does not serve as a unifying theory in pedagogy (Phillips 2000). The findings of the study support this contention. The Zimbabwean groups perceived their learning environment as relatively more constructivist than the American group with regard to the uncertainty and student negotiation dimensions. Nonetheless, the two groups were equally satisfied with their overall educational milieu.

Additionally, the two groups perceived their learning environment the same with regard to the critical voice dimension. However, the Zimbabwean sample indicated higher satisfaction than the American group with the learning environment. Although Dunkhase, Hand, Shymansky, and Yore (1997) suggested that constructivism was a better approach if teachers are to have a more positive attitude and more favorable perception of teaching, the findings of the current study make it difficult to draw any conclusions as to which environment is best suited for statistics instruction.

In their study, Aldridge, Fraser, and Huang, (1999) found that Australian students viewed their environment more favorably than the Taiwanese students, but that the Taiwanese students had a more positive attitude than the Australian students. However, other researchers (see, for example, Wong and Fraser 1994; Dunkhase et al. 1997; Henderson, Fisher, and Fraser 1998) found that when the learning environment was more constructivist, students had a better attitude toward the subject. Based on these studies, it is not surprising that Zimbabwean students were found to have a more positive attitude given that they perceived their environment as more constructivist. Although the results indicate a relationship between a constructivist environment and students' attitude, we should be careful not to imply causation.

Additionally, Zimbabwean students were found to have a better person-environment fit. This finding, in conjunction with the significant difference in attitude, supports the theory that a better person-environment fit leads to a better attitude toward the subject (Fraser and Walberg 1998).

The significant correlation between student negotiation and attitude and the identification of students negotiation as the best predictor of achievement support both Vygotsky's (1978) and Dewey's (1916) theory that effective learning requires social interaction not just individual construction. Dewey (1916) also theorized that knowledge construction is better when it is meaningful to the learner and this is
supported by the significant relationship between personal relevance and attitude.

6. Limitations of the Study

The nature of the research design prevents drawing any firm conclusions from the data. Because the study involves perceptions of the classroom environment rather than actual measures, one cannot clearly determine the level of constructivist pedagogy. Inferences about differences between the two groups and relationships among variables should be cautiously drawn.

There are obviously some limitations associated with cross-cultural research. Koebley and Soled (1998) pointed out that teaching math was often different in developing countries. For example, the potential for math to enhance critical thinking, self expression, and cultural and social awareness may lead to a threat to established institutions of power in countries where these ideas are taught.

Furthermore, Zimmer and Fuller (1996) and Wilson (1997) identified technical issues, such as computer anxiety and computer skills, as factors impacting performance in statistics and students attitude toward statistics. Given the difference in technological development between Zimbabwe and the US, this may have confounded the results. This study assumed that the two samples were relatively comparable. In view of the fact that (a) the samples were not matched, and (b) the factor structures of the instruments were not entirely replicated across cultures, comparability may be compromised. Securing like groups in disparate cultures was problematic. Furthermore, the unequal gender distribution for the samples raised additional concerns about the reliability of the results.

Finally, the sample was chosen on the basis of convenience. The disadvantage of using such a non-random sample is that it is difficult to generalize the finding to other groups of American and Zimbabwean college students.

7. Implications for Practice and Concluding Remarks

Nonetheless, there are some implications for practice to be drawn from these findings. Personal relevance appears to be important to the success of students in statistics education. For this US sample personal relevance was identified as the most important predictor of attitude toward statistics. Applied statistics should be taught in the context of real-world problems (Gordon 1995; Hubbard 1997). In the context of the current study, bridging the gap between reality and numbers is particularly important to the instructors of the US sample. Applying statistics to real-world situation can reduce anxiety in the statistics classroom (Yager and Wilson 1986; Tobias 1991; Schacht and Stewart 1992; Stallings 1993). Instructors can also work to reduce anxiety in the statistics classroom by creating a social setting in the learning environment. This would address the student negotiation component of the CLES. They could do this by encouraging students to work in small cooperative groups (Burton 1984; Blum-Anderson 1992; Mealey and Host 1992).

Zimbabwean instructors should encourage student communication with experts and peers, in solving statistical problems. This idea of scaffolding (Wood, Bruner, and Ross 1976) seems to be of particular relevance to the success of the Zimbabwean sample. For this group student negotiation was identified as the most important predictor of students' attitude toward statistics.

Instructors in both locations should also note all the dimensions that were significantly correlated to attitude even if they were not identified as the best predictors (for example, uncertainty and critical voice). These indicate that for both samples a "safe" environment is desirable if students are to have a positive attitude toward statistics. It is also important to note that the Zimbabwean sample perceived their
learning environment as more constructivist and also had a more positive attitude toward statistics. This implies that if teachers use constructivist strategies, thereby creating a more constructivist environment, their students may have a better attitude toward the class.

The significant relationship between person-environment fit and attitude suggests that teachers should work to achieve a close person-environment fit. Although we cannot conclude that a cause and effect relationship exists, an association of the variables is strongly implied. As Harvey et al. (1985) concluded, a supportive atmosphere can help achievement in the statistics course regardless of the student's attitude toward the field of statistics. Research has shown that attitudes are complex and difficult to change but it may be that teachers can influence them through the learning environment. Attempting to build strong positive attitudes toward statistics and making statistics relevant to students' "real" world will go a long way in encouraging students to use their knowledge outside the classroom (Garfield, Hogg, Schau, and Whittinghill 2002).

The study examined the similarities and differences in perceptions and attitudes of students from two very different learning milieus. Cross-cultural comparisons have the potential to generate new insights into statistical pedagogy and the role noncognitive socio cultural variables play in teaching statistics to college-age students. Perhaps, in the future, to enhance student attitudes toward statistics instructors will move away from primarily using didactic methods and in their stead try out more constructivist approaches.

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