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REGULAR ARTICLE

Investigating the Pedagogical Approaches Related to Changes in Attitudes Toward Statistics in a Quantitative Methods Course for Psychology Undergraduate Students

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Abstract The purpose of this study was to examine the extent to which the pedagogical approaches used in the course were related to improvements in students' attitudes toward statistics in a Quantitative Methods course for psychology undergraduate students in a Malaysian University. The study examined whether increasing availability of the instructor and tutor, carrying out hands-on activities, using collaborative learning, and utilizing scaffolding activities would be related to the improvement of students' attitudes toward statistics. It also hypothesized that the various pedagogical approaches used would be related to higher levels of achievement in statistics. One hundred and three psychology students from a 14-week undergraduate course on statistics volunteered to participate in this study. The study found partial support that the approaches utilized were related to positive attitude changes toward statistics as well as achievement. Limitations are discussed and future research is suggested.

Keywords Attitudes toward statistics · Statistics anxiety · Student-centered learning · Active learning · Pedagogy for undergraduate statistics

Undergraduate students in psychology are usually required to take statistics as part of their coursework, but anecdotally, students often dread their statistics courses and develop negative attitudes toward them (Keeley et al. 2008; Onwuegbuzie and Wilson 2003). For example, a recent study showed that 39 % of students who majored in psychology reported negative attitude toward statistics (Griffith et al. 2012). These students may develop anxiety toward statistics, feeling that it is a difficult subject; they may also think statistics is not useful in their lives, believing that they do not have to be competent in statistics (Gal et al. 1997; Schau et al. 2012). Research has shown that difficulty of the subject, non-use in future career and dislike of mathematics were listed as the major reasons for negative attitudes toward statistics (Griffith et al. 2012; Schau et al. 2012). Schau (2003) has argued that these attitudes about statistics constitute the "other" important outcome in statistics education. In other words, the purpose of statistics education is not only to improve students' understanding and ability in statistics but also to develop positive attitudes toward statistics.

These attitudes play an important role as students with negative attitudes can create an uncomfortable classroom climate (Gal et al. 1997). In addition, there are moderate to large links between initial statistical attitudes and subsequent performance (Cherney and Cooney 2005; Harlow et al. 2002; Hood and Neumann 2012). For example, Cherney and Cooney (2005) found that higher levels of statistics anxiety were related to lower grades in an undergraduate psychology course. Hood et al. (2012) found that perceived difficulty, competence, and expectations directly or indirectly predicted university students' achievement in their psychology statistics course after controlling for their past performance.

Numerous studies have developed ways to measure attitudes toward statistics (e.g., Nolan et al. 2012; Zaneski and Valenzi 1997) and examined the relationship between attitudes and performance (e.g., Keeley et al. 2008), but

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few studies have investigated ways to improve attitudes toward statistics for undergraduate students. The purpose of this study was to examine the extent to which the pedagogical approaches used in the course were related to improvements in students' attitudes toward statistics in a Quantitative Methods course. The course was an introductory statistics for psychology course which was a part of the core curriculum for first-year psychology undergraduates.

Conceptual Framework for Improving Students' Attitudes Toward Statistics

In order to develop a course to improve students' attitudes toward statistics, we wanted to utilize approaches that were based on empirical research. In Garfield and Ben-Zvi's (2007) review of research on the teaching and learning of statistics, the authors recommended that statistics educators should use empirically-based principles of learning. These principles tend to promote learning for understanding and the development of learner-centered environments. Bransford and colleagues (National Research Council 2000, 2005) in their comprehensive review of effective teaching and learning, have stated four important principles of learning. First, learning environments must be learner-centered. "Teachers must pay close attention to the knowledge, skills, and attitudes that learners bring into the classroom" (National Research Council 2000, p. 23). Second, teachers should foster a knowledge-centered environment. In such an environment, learning with understanding or sense-making is emphasized in order for students to gain mastery and a deeper understanding of the material. Third, formative assessments, i.e., "ongoing assessments designed to make students' thinking visible to both teachers and students" (p. 24),—are essential. Fourth, a community-centered environment where there are norms for people to learn from one another is important for learning.

Pedagogical Approaches Utilized Based on the Conceptual Framework

Following the National Research Council's four principles, we incorporated the following four general pedagogical approaches in the first-year core course in Quantitative Methods—increasing accessibility of the instructor and tutor, carrying out hands-on activities, using collaborative learning, and utilizing scaffolding activities. In this section, we outline the approaches used, and how they addressed the principles of learning.

The National Research Council (2000, 2005) has argued that educators need to be sensitive to the attitudes that students bring to a course. As mentioned above, one of the problems that statistics educators face in teaching statistics to non-mathematical students is that students tend to have negative attitudes toward statistics; in particular, they tend to be anxious about such a course (Gal et al. 1997). In order to address this anxiety, accessibility to the instructor and tutor throughout the course was emphasized to the students. The instructor and tutor's email addresses were provided to all students, and students were informed that they could ask questions through e-mail; time was allocated before, during, and at the end of each class for students to ask questions (see items 9, 10, 11 and 12 in Table 1). Pan and Tang (2005) have recommended that increased accessibility via having flexible and extra office hours was an important component of their effort to reduce statistics anxiety in a graduate statistics course for the social sciences.

Second, a key component of a knowledge-centered environment is that it emphasizes learning that leads to understanding and application. Such an environment encourages students to "build on their informal ideas in a gradual but structured manner so that they acquire the concepts and procedures of a discipline" (National Research Council 2000, p. 137). Pfannkuch (2005) suggested that emphasizing actual experience with data exploration was an effective strategy in promoting the understanding of the relations among different statistical concepts, and Shaughnessy (2007) has recommended that students use data sets before being introduced to the formal concepts of statistics. Therefore, we decided to give students an assignment that involved carrying out a hands-on research project in this course to promote their deep understanding. Given the emphasis on sense-making in knowledge-centered environments, the research project gave students the hands-on opportunity in their groups to experience the usefulness of statistics as they learned how to apply their knowledge of statistics to analyzing real data—data that were based on research that they designed and collected themselves. Research has indicated that learners are more motivated when they see the utility of what they are learning (McCombs 1996); in this research project, students had to use the statistical tests they learned to address the hypotheses in their projects. Dolinsky (2001) has argued that the use of such active learning techniques helps to instil pride and self-confidence in students, and has been recommended in higher education (e.g., Brundiers et al. 2010). Although this class focused on statistical concepts and calculations, students were also given the hands-on experience to use SPSS, a user-friendly statistical software, that allowed students to analyse their own data. In summary, we attempted to create a knowledge-centered environment by getting students to engage in a hands-on project which gave them the opportunity to understand the material better and to apply their new knowledge to analyzing real-world data (see items 1, 2, 3, and 4 in Table 1).

Table 1 Items, communalities, and factor loadings for the student perceptions of effective pedagogical approaches scale (SPEPAS)

	Item	Factor 1		Factor 2		Factor 3		Factor 4		
		Use of scaffolding activities		Accessibility of instructor and tutor		Collaborative learning		Hands-on approach		
		Pat.	Str.	Pat.	Str.	Pat.	Str.	Pat.	Str.	h^2
5	The tutorial activities	**0.80**	**0.83**	0.07	0.30	0.13	0.39	−0.13	0.12	0.62
6	The practice quizzes	**0.79**	**0.88**	0.11	0.33	0.07	0.44	0.15	0.38	0.81
7	Having formulas for the quizzes	**0.42**	**0.56**	0.37	0.50	0.10	0.38	0.07	0.22	0.83
8	Discussing difficult concepts with my group mates	**0.63**	**0.77**	0.01	0.25	0.28	0.56	0.14	0.40	0.80
9	Being able to ask the instructor questions through e-mail	−0.33	−0.01	**0.73**	**0.70**	0.09	0.36	0.45	0.44	0.85
10	The instructor is available before, during, and after class for questions	0.09	0.28	**0.85**	**0.88**	0.06	0.31	−0.11	−0.02	0.73
11	Accessibility of the instructor	0.06	0.26	**0.88**	**0.90**	0.05	0.29	−0.12	−0.05	0.82
12	Accessibility of the tutor(s)	0.31	0.44	**0.75**	**0.81**	−0.01	0.26	−0.16	−0.06	0.47
13	Group Work	−0.03	0.31	0.11	0.38	**0.90**	**0.90**	−0.07	0.26	0.67
14	Learning statistics with my group mates	0.02	0.31	−0.10	0.18	**0.89**	**0.87**	0.00	0.32	0.83
15	Working on the project with my group mates	−0.03	0.31	0.12	0.38	**0.86**	**0.89**	0.00	0.30	0.76
16	Learning to run the tests in class using SPSS.	0.19	0.46	−0.05	0.21	**0.65**	**0.77**	0.18	0.46	0.75
1	The hands-on practice of learning statistics by using SPSS	0.33	0.53	−0.09	0.11	0.32	0.57	**0.43**	**0.62**	0.83
2	The hands-on practice of learning statistics in class in your project groups	0.04	0.28	−0.04	0.04	0.09	0.41	**0.86**	**0.91**	0.74
3	The hands-on practice of learning while working on your projects	0.00	0.24	−0.11	−0.03	0.13	0.41	**0.87**	**0.91**	0.80
4	The hands-on practice of learning statistics through the in-class assignments	0.60	0.70	0.07	0.19	−0.19	0.26	**0.62**	**0.70**	0.70
	Eigen values	6.67		2.63		1.49		1.20		

The coefficients in bold link the items to their respective factors

Pat pattern matrix coefficients, *Str* structure matrix coefficients

In order to create an environment that emphasizes formative assessment, i.e. regular feedback to improve teaching and learning, various activities were introduced to scaffold students' learning. Garfield and Ben-Zvi (2007) have argued that students learn to do well only what they practice doing. Delmas et al. (2007) have argued for the importance of assessing students' understanding of basic statistics concepts step by step. In other words, students learn more critically if they are permitted and encouraged to do things over and over in different contexts. Hence, in the course, students were given five graded tutorial activities, seven graded practice quizzes, and opportunities to discuss difficult concepts with their group mates. In each lesson, students were walked through different types of statistical questions for each topic, and clear explanations were provided for all statistical terms used (see items 5, 6, 7 and 8 in Table 1).

To create a community-centered environment, students were encouraged to work in groups. One example of the use of collaborative learning was the above mentioned project which was completed in project teams of four or five students. Above and beyond the project, students were also encouraged to work on statistical problems, and to experience using statistical software such as SPSS in groups during and after classes (see items 13, 14, 15 and 16 in Table 1). Magel (1998) found preliminary evidence that collaborative learning in a large undergraduate statistics class was associated with improved achievement scores. Perkins and Saris (2001) suggested that cooperative learning techniques foster positive attitudes toward statistics learning and further benefit students' achievement. The benefits of collaborative learning is also supported by research conducted in Asian contexts (e.g. Hung et al. 2009; Osman et al. 2011; Pan et al. 2010). In general, the classroom learning environment has been found to be an important factor that contributes to the overall experience of undergraduate learning (Pan et al. 2010).

Hypotheses

The first objective of the current study was to develop and validate an instrument to assess students' perceptions about which of the pedagogical approaches used were helpful in

alleviating their anxieties about the course. Exploratory factor analyses were conducted to provide preliminary validation of the scale. The second objective of the study was to examine whether the various pedagogical approaches used in the course would be related to improvement of students' attitudes toward statistics and achievement. We hypothesized that the various pedagogical methods would be associated with changes in students' attitudes toward statistics. In particular, we examined whether the accessibility of the instructor and tutor for assistance in learning, the use of hands-on activities, the use of scaffolding activities, and the use of collaborative learning would be related to the improvement of students' attitudes toward statistics. Third, we hypothesized that the various pedagogical methods used would be related to higher levels of achievement in statistics. The hypotheses are supported by the work of various researchers (Magel 1998; Pan and Tang 2004; Zaneski and Valenzi 1997), who have found that they can improve students' attitudes, decrease their anxiety toward statistics, and improve achievement by using more constructivist or active-learning techniques in their classes.

Method

Participants

One hundred and three psychology students, 30 men and 73 women, from a 137-student 14-week core undergraduate introductory course on statistics volunteered to participate in this study. In regard to self-reported ethnicity, 69 (67.0 %) were Chinese, 17 (16.5 %) were Indian, 7 (6.8 %) were Malay, 9 (8.7 %) were of other races and 1 (1 %) did not provide any information on ethnicity. Participants age ranged from 17 to 31 ($M = 20.17$, SD = 2.03). Students were from a Malaysian private university.

Out of the 103 students who joined at the start, 66 students remained with the study to its completion. Details on the attrition analyses conducted on the 37 students who chose to leave the study are presented in the results section. In regard to the 66 students who stayed with the study, 46 (69.6 %) were Chinese, 10 (15.2 %) were Indian, 6 (9 %) were Malay, 4 (6 %) were of other races. Their self-reported ages ranged from 18 to 28 ($M = 19.8$, SD = 1.50).

Measures

Two measures were administered in this study: The Survey of Attitudes toward Statistics (SATS; Schau et al. 1995) and the Effective Pedagogical Approaches Scale (EPAS; Liau and Kiat 2009).

The Survey of Attitudes toward Statistics The Survey of Attitudes toward Statistics (SATS; Schau et al. 1995) was used to assess students' attitudes toward statistics. Permission to use the scale had been granted by the lead author of the scale. The 36-item scale contained 6 subscales: Affect (6 items) measured student feelings concerning statistics (e.g., "I will like statistics"); Cognitive Competence (6 items) measured students' attitudes about their intellectual knowledge and skills when applied to statistics (e.g., "I will understand statistics equations"); Value (9 items) measured students' attitudes about the usefulness, relevance, and worth of statistics in their personal and professional life (e.g., "Statistical skills will make me more employable"); Difficulty (7 items) measured students' attitudes about the difficulty of statistics as a subject (e.g., "Statistics formulas are easy to understand"); Interest (4 items) measured students' level of individual interest in statistics (e.g., "I am interested in understanding statistical information"); Effort (4 items) measured the amount of work the student expends to learn statistics (e.g., "I plan to complete all my statistics assignments;" Schau 2005). Each item was rated on a 7-point scale, where 1 = Strongly Disagree, 4 = Neither Disagree nor Agree, and 7 = Strongly Agree. All the scales were scored in such a way that higher scores indicated more positive attitudes. With the exception for the Difficulty scale, the Cronbach α's for both the pretest and posttest subscale scores ranged from 0.82 to 0.90, indicating good internal consistency. The Cronbach α's for the difficulty scale was 0.67 and 0.66 for the pretest and posttest, respectively.

Students' Perceptions of Effective Pedagogical Approaches Scale (*SPEPAS*) SPEPAS was developed for the purpose of the current study to assess students' feedback regarding the effectiveness of the various pedagogical approaches used in the course to improve students' attitudes toward statistics. The 16-item EPAS was conceptualized to examine the four approaches used in this course: the Accessibility of the Instructor and Tutor for assistance in learning, the Hands-on Approach, the Use of Scaffolding Activities, and the Collaborative Learning. The Accessiblity of the Instructor and Tutor for assistance in learning involved students having access to guidance from the instructor and tutor (4 items). The Hands-on Approach involved active learning activities that emphasize understanding and application (4 items; the items can be found in Table 1). The Use of Scaffolding Activities involved efforts to provide regular guidance and feedback to improve learning (4 items). Collaborative Learning included learning activities that involved working in groups (4 items). Participants rated their agreement with a course aspect being instrumental in reducing their anxiety regarding statistics by rating each item on a 5 point scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. An exploratory factor analysis, using principle components analysis with an

oblique oblimin rotation, was conducted to examine the factor structure of SPEPAS scores.

Academic Achievement The final grade obtained for the course was used as a measure of academic achievement in the subject. The maximum possible score was 100. The breakdown of marks for the course was as follows: quizzes (10 % of overall), a group-based research project (30 %) and one final examination (60 %). The quizzes and research project were graded by tutors assigned to the course, and the final examination was based on 50 multiple-choice questions, and 10 short-answer questions graded by the instructor.

Procedure

The present study was approved by the ethical review board for the institution. On the first day of class, students were informed that the researchers (the instructor and tutor of the course) would be conducting a study on students' attitudes toward statistics throughout the course. Students were informed that participation in the study was on a voluntary, no compensation basis. The pre-test version of the SATS was then distributed to the students who volunteered to participate. The course then proceeded for a period of 14 weeks. In the final class of the course, the post-test version of the SATS as well as the SPEPAS were distributed to the students who had participated in the pre-test stage and who were willing to continue their participation in the study.

Results

Attrition Analyses

Attrition analyses showed that the 37 students who dropped out of the study did not differ from the follow-up participants in regard to age or any of the SATS subscales at the $p < 0.05$ level with the exception of the effort subscale where students who dropped out had significantly lower effort scores ($M = 23.90$, SD $= 3.22$) compared to the follow-up students ($M = 25.01$, SD $= 4.76$), $t(101) = 2.62$, $p < 0.05$. The post-test was conducted in the final class of the course which was a review session, and hence, a number of students may have opted not to attend the final class.

Changes in Attitudes Toward Statistics

To evaluate changes in attitudes on the 6 SATS subscales from the pre-test to the post-test, six paired-sample t tests were conducted (see Table 2). The results of the t tests indicated that there were significant positive changes in attitudes toward statistics for the Affect and Cognitive Competence subscales. There was a significant negative change in attitudes toward statistics on the Effort subscale. There were no significant changes in the other three attitudes toward statistics.

Exploratory Factor Analyses of the SPEPAS

Prior to conducting factor analysis, two indicators were examined to determine whether the sample was appropriate for such an analysis. The Kaiser–Mayer–Olkin measure of sampling adequacy was 0.88, and the Bartlett's test of sphericity was significant, χ^2 (120, $N = 66$) $= 697.88$, $p < 0.0001$, indicating that the sample and correlation matrix were appropriate for exploratory factor analysis. The factor structure of the SPEPAS was explored using principle component analysis with an oblique Oblimin extraction method as the factors were expected to be correlated.

Multiple criteria, as recommended by Gorsuch (1983), were used to determine the number of factors to retain. The criteria used included: eigenvalues > 1 (Guttman 1954), Horn's parallel analysis (Horn 1965), minimum average partials (Velicer 1976), the interpretability of the factors, and the a priori criterion based on the hypothesized structure of the SPEPAS. All the criteria recommended the extraction of four factors.

After rotation, a four factor solution that accounted for 74.95 % of the variance in SPEPAS scores was produced. All items had loadings greater than 0.40 on their relevant factor. The factor pattern and factor structure coefficients are presented in Table 2, along with communalities (h^2) of the measured variables, and the eigenvalues of the factors. All 22 items had communalities of at least 0.62. The first three-item factor accounted for 41.69 % of the variance, and was labeled Use of Scaffolding Activities. The second four-item factor accounted for 16.41 % of the variance, and was labeled Accessibility of Instructor and Tutor. The third four-item factor accounted for 9.34 % of the variance, and was labeled Collaborative Learning. The fourth five-item factor consisted accounted for 7.52 % of the variance, and was labeled the Hands-on Approach. Table 3 presents the SPEPAS subscale means, standard deviations, inter-correlations, and the Cronbach's α coefficients for the four factors; all of the Cronbach's α coefficients were at good levels.

Effective Pedagogical Approaches Associated with Changes in Students' Attitudes Toward Statistics

To identify the pedagogical approaches used in the course that were associated with the observed changes in students' attitudes toward statistics, multiple regression was used to examine in a multivariate approach, whether each of the four SPEPAS factors predicted the six SATS post-test

Table 2 Pre-test to post-test changes in attitudes toward statistics

Scale	Pretest mean (SD)	Posttest mean (SD)	*t*	Cohen's *d*
Affect	22.58 (7.61)	25.22 (8.21)	3.80**	0.48
Effort	23.90 (3.96)	22.00 (4.51)	−2.98**	0.36
Interest	16.36 (5.96)	16.52 (5.90)	0.33	0.04
Difficulty	23.00 (6.19)	23.85 (5.81)	1.22	0.15
Value	40.08 (8.97)	41.12 (10.73)	0.05	0.01
Cognitive competence	26.09 (7.21)	27.63 (7.20)	2.50*	0.30

* $p < 0.05$; ** $p < 0.01$ (2-tailed)

scores controlling for the relevant pre-test SATS score and the other SPEPAS factors.

Before the regression analyses were conducted, all models were examined to ensure that they met the statistical assumptions of regression analysis. Multicollinearity among the predictors was examined and was not problematic as all predictors had variance inflation factor values below 2.5. With the assumptions met, analysis proceeded with a forced-entry simultaneous approach being used in all the analyses. All the SATS post-test scores were regressed onto the SPEPAS factors with the respective pre-test score controlled for in six separate models. A summary table of the results is presented in Table 4. The Hands-on Approach factor was a significant predictor of post-test Effort and Value scores. Use of Scaffolding Activities was a significant predictor of post-test cognitive competence and affect scores. Availability of Instructor and Tutor was a significant predictor of both post-test Effort. Collaborative Learning was not a significant predictor in any of the models.

Relationship Between Perceptions of Factor Effectiveness and Grades

To evaluate the relationship between SPEPAS and the overall grades for the course, Pearson correlation coefficients between the two were calculated. Results indicated that Use of Scaffolding Activities, the Hands-on Approach, and Collaborative Learning were correlated with overall grades (see Table 3). Availability of Instructor and Tutor was not related to overall grades.

Discussion

Based on established learning principles, a number of approaches were used in a first-year psychology undergraduate core Quantitative methods course to improve students' attitudes toward statistics. These methods included increasing accessibility of the instructor and tutor, carrying out hands-on activities, using collaborative learning, and utilizing scaffolding activities. Psychometric data from this study provided evidence for the reliability and factorial validity of a scale that was developed to assess students' perceptions about effective pedagogical approaches used in the course. The objective of the study was to investigate the extent to which these techniques, based on students' self-ratings, were related to changes in students' attitudes toward statistics and achievement.

As an initial step, we investigated changes in attitudes toward statistics from the beginning to the end of this course. The analyses indicated evidence for positive changes in affect and cognitive competence, but a negative change in effort. The other aspects of attitudes toward statistics—interest, difficulty, and value—did not change. The positive change in affect was important as the study provided evidence that the course met one of its objectives—reducing students' statistics anxiety. The increase in cognitive competence supports the notion that students felt more confident about statistics by the end of the course. These findings are consistent with studies indicating that the use of constructivist or active-learning techniques can improve students' attitudes toward statistics (Magel 1998;

Table 3 Factor correlations, means, standard deviations and internal consistency reliabilities for the subscales of the student perceptions of effective pedagogical approaches scale

	1	2	3	5	*M*	SD	α
1. Use of scaffolding activities				0.35**	15.86	3.33	0.82
2. Accessibility of instructor and tutor	0.44**			0.14	15.52	3.44	0.84
3. Collaborative learning	0.58**	0.40**		0.29*	14.59	3.87	0.88
4. Hands-on approach	0.56**	0.15	0.53**	0.33**	14.85	3.54	0.86
5. Overall grades					68.94	13.90	

* $p < 0.05$; ** $p < 0.01$

Table 4 Post-test survey of attitudes toward statistics scale (SATS) scores regressed onto students' perceptions of effective pedagogical approaches scale scores and SATS pre-test scores

	B	SE *B*	*β*
Outcome variable: effort			
Pretest score for effort	0.19	0.13	0.17
Hands-on approach	0.44	0.18	0.35*
Collaborative learning	−0.07	0.17	−0.06
Use of scaffolding activities	−0.01	0.21	−0.01
Availability of instructor and tutor	0.40	0.17	0.31*
Outcome variable: interest			
Pretest score for interest	0.63	0.09	0.64**
Hands-on approach	0.25	0.17	0.15
Collaborative learning	−0.09	0.16	−0.06
Use of scaffolding activities	0.40	0.21	0.12†
Availability of instructor and tutor	−0.07	0.16	−0.04
Outcome variable: difficulty			
Pretest score for difficulty	0.43	0.12	0.47**
Hands-on approach	0.14	0.22	0.09
Collaborative learning	0.09	0.21	0.06
Use of scaffolding activities	0.19	0.25	0.11
Availability of instructor and tutor	−0.40	0.21	−0.25†
Outcome variable: value			
Pretest score for value	0.77	0.1	0.65**
Hands-on approach	0.63	0.30	0.21*
Collaborative learning	−0.09	0.29	−0.03
Use of scaffolding activities	0.45	0.37	0.14
Availability of instructor and tutor	0.08	0.30	0.02
Outcome variable: cognitive competence			
Pretest score for cognitive competence	0.7	0.09	0.69**
Hands-on approach	0.31	0.20	0.16
Collaborative learning	−0.01	0.19	−0.01
Use of scaffolding activities	0.49	0.24	0.23*
Availability of instructor and tutor	0.09	0.19	0.04
Outcome variable: affect			
Pretest score for affect	0.86	0.1	0.78**
Hands-on approach	−0.32	0.28	−0.13
Collaborative learning	0.25	0.25	0.12
Use of scaffolding activities	0.65	0.30	0.25*
Availability of instructor and tutor	−0.03	0.23	−0.01

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$ (all two-tailed)

Pan and Tang 2004; Zaneski and Valenzi 1997). However, the finding that there was a decrease in effort is puzzling. The post-test assessment was done at the end of the course, during the time where assignments were due. Perhaps students felt that they had not put enough effort in their assignments.

Multiple regression analyses with the students' perceptions of pedagogical approaches as predictors were run to examine the multivariate effects of the four techniques on changes in attitudes toward statistics in the six domains. The hands-on approach was significantly related to positive change in effort and value. This finding is consistent with the previous studies which support the benefits of hands-on experiences and contextualized questions in statistics learning (Pfannkuch 2005; Shaughnessy 2007). The use of scaffolding activities approach was significantly related to positive change in cognitive competence and affect. Similarly, Kao and Lehman's (1997) research also supported the use of scaffolding in the teaching and learning of statistics. The availability of instructor and tutor approach was

significantly related to positive change in effort. Consistent with the findings and recommendations of Pan and Tang (2005), this approach is a simple and practical strategy to reduce students' anxiety toward statistics.

All of the approaches except for the availability of instructor and tutor were associated with overall grades. Hence, the study found partial support that these learner- and knowledge-centered techniques utilized in an assessment- and community-based environment were related to a positive attitude changes toward statistics as well as achievement. These findings are consistent with Harlow et al. (2002) study which found that students experiencing a learning-enhanced quantitative course involving peer mentoring, question and answer sessions, a consultation corner, and hands-on learning had a significant reduction in their mathematics anxiety and significantly increased their self-efficacy for statistics over the course of a semester. In sum, these findings suggest that a focus on promoting learning for understanding and developing assessment-centered learning environments are key to promoting the learning of students (National Research Council 2000).

Garfield and Ben-Zvi (2007) have stated that it is easy to underestimate the difficulty that students face in understanding basic concepts of statistics. Hence, it is important that we develop evidence-based techniques to help students construct knowledge and be involved actively in their learning of statistics. Although a number of studies have shown that changes in students' attitudes from the beginning to the end of the course are possible (Magel 1998; Pan and Tang 2004; Zaneski and Valenzi 1997), none of these studies has tried to identify which techniques are related to the changes in attitudes. A major contribution of this study is that it represents a preliminary step in identifying the specific pedagogical techniques that help improve students' attitudes toward statistics, and their achievement in statistics.

The results of this study are limited by the use of one undergraduate class in a Malaysian University. The study did not have any experimental features and the presence of learning activities was not manipulated. Hence, given the correlational nature of the data, instead of the pedagogical techniques influencing students' attitudes, it is possible that students with improved attitudes might rate the instructors' pedagogical approaches as higher than students whose attitudes became worse. Although approaching the acceptable range, the reliability for the difficulty subscale of the SATS was in the questionable range, and should be improved in future research. While the study examined changes in attitudes toward statistics, changes in statistical achievement were not measured. Researcher expectancy effects may also be present given that the instructor and tutor were the researchers conducting the study. Given the lack of improvement in attitudes toward statistics with regard to the value and difficulty of statistics, as well as interest in statistics, more research needs to be done to consider ways to improve these aspects of students' attitudes. Hence, future studies could be conducted using a larger sample involving numerous classes utilizing a number of different instructors and tutors. An experimental design can be used to identify pedagogical techniques that are associated not only with changes in attitudes but also changes in achievement.

In conclusion, this study represents a preliminary step in identifying pedagogical techniques that are useful in improving students' attitudes toward statistics and statistics achievement. A variety of pedagogical approaches were developed and found to be promising in influencing both students' attitudes and their achievement in a first-year quantitative methods course. Subsequent research can be done to investigate whether the results from this correlational study can be verified with an experimental design.

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