Man In India, 97 (24-II) : 313-322

EVALUATING THE EFFECTIVENESS OF NEW APPROACH IN TEACHING ELEMENTARY STATISTICS

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Elementary Statistics is commonly taught across multiple disciplines in higher educational institutions for its fundamental knowledge and widespread applications. As such, this course involves substantial resources, and any failures often result in retaking the course, which further burdens the institution. Lecturers are continually challenged to enhance their teaching for effective students learning. Teaching effectiveness in itself is rather a complex subject matter. The methods to evaluate teaching effectiveness are varied and largely dependent on the purpose of evaluation. This paper reviews various methods of evaluating the effectiveness of a new approach in teaching elementary statistics, with emphasis on the use of surveys on attitude toward statistics. A pilot study was conducted on a group of university undergraduate students, gathering their feedback before and after the implementation. The new teaching approach was found effective in improving overall students' performance as well as their attitudes toward statistics. In particular, the affect attribute concerning students' feelings about statistics was significantly better, which helps them learning more effectively.

Keywords: Elementary Statistics, Statistics education, teaching effectiveness, higher education.

I. INTRODUCTION

Elementary course in statistics is often a mandatory requirement for graduation in almost all programmes in higher education institutions. Nevertheless, it is often perceived by many students as unavoidably unpleasant, if not tough or "killer". The challenge is for the lecturers to find ways to make teaching and learning of elementary statistics effective, especially for non-science students who tend to be uncomfortable, if not intimidated by symbols and numbers. Researchers have reported that combining teaching and learning innovations in higher education with the appropriate use of technology, has resulted in improved student performance and substantial cost savings (Harkness, Lane, & Harwood, 2003). Rapid technology advancement can benefit educational activities, but ensuring its effectiveness is in itself a complex equation yet to be solved.

In general, higher education institutions have focused mainly on research outputs as their major performance indicators, inadvertently side-lining the core teaching function (Ramsden, 1991). It is imperative that teaching effectiveness is important because effective teaching helps student learning. It has become even more critical as the emphasis on quality in higher education has increased over the decades. Nevertheless, effectiveness of teaching and its evaluation in higher educational institutions remain debatable. The methods of evaluation is highly

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dependent on the purpose. For example, evaluations to improve teaching practice and design are referred to as formative evaluation. Meanwhile, summative evaluations used in making decisions such as job promotion.

This paper reviews several forms of the formation evaluations involving students, peers and the lecturer. The main focus is on the effect of a new teaching approach to the core attributes of students' attitude toward statistics. Additionally, the overall student performance and their feedback are briefly discussed.

II. TEACHING OF ELEMENTARY STATISTICS

The conventional method of teaching elementary statistics is teacher-centred which is a passive learning. Previously, the approach of group assignments is examination-oriented and does not encourage in-depth statistical thinking. Students have the tendency to memorize steps in calculation without clearly understanding the scenario in order to interpret the calculated values. To improve the teaching and learning of this course, a new teaching approach was developed and implemented. In Malaysia, E-Learning is one of the Critical Agenda Projects (CAPs) and a National Key Result Area (NKRA) of the Malaysian Ministry of Higher Education (Embi, 2011). It is envisioned that majority of university courses are moving towards blended learning. An important learning principle is that students learn best when they are actively involved in the learning process. According to the pyramid of teaching effectiveness (Booth, 2011), typically students remember 10% by reading, 20% by listening, 30% when assisted with visual aids, 50% with live demonstrations, 70% via discussions and 90% by doing the real thing.

The new teaching approach incorporates e-learning and student-centred learning to engage students effectively. It promotes students to explore data, discover new information and draw inferences from the data by experiences they received in group discussions and activities. Aligned with Malaysia's CAPs and NKRA, the technology such as web 2.0 tools were adopted in teaching and learning of this course. Students were given learning materials prior to the lessons and consistently reminded to prepare before class.

(A) Evaluation of Effectiveness

Teaching evaluation of effectiveness is an educational responsibility for academics, arising from a genuine commitment to understanding the effects of teaching on students and to enhance student learning. Teaching effectiveness is defined and evaluated in numerous ways, since there is lack of consensus on the characteristics of effective teaching (Shevlin *et al*., 2000). A substantiated review of this topic is given by Mittal and Gera (2013), who developed a student evaluation of teaching effectives for higher education in India. Earlier, Beck (2005) identified twelve potential sources of evidence of teaching effectiveness: student ratings, peer reviews, self-reviews, videos of practice, student interviews, alumni, employer and

administrator ratings, teaching awards and scholarship, learning outcome measures, and teaching portfolios.

In many universities, student ratings is the most common measurement of teaching effectiveness, but its validity and reliability continue to be questioned. Shevlin *et al*. (2000) examined the relationship between external factors and student ratings of teaching effectiveness and argued that lecturer's charisma (personal quality of leadership) affects student's judgment including that of teaching effectiveness.

In this paper, the change of students' attitudes toward statistics is investigated instead of the conventional student ratings of the course (which is already assessed by the institution).

(B) Attitude and Performance

Conceptually, attitude is concerned with an individual's way of thinking, acting and behaving. Maio *et al*. as cited by Mensah *et al*. (2013) divided attitude into of three major components: cognitive, affective and behavioural. The cognitive component of attitude is what a person thinks or believes about the attitude object. The affective attribute concerns with the feelings or emotions of the individual associated with the attitude object. Meanwhile, the behavioural aspect is the tendency to respond in a particular way to the attitude object. Students attitudes are formed as a result of learning experiences they go through. By the time they reach the university, they would have gone through more than ten years of school education comprising both positive and negative experiences.

Researchers have reported that students attitudes toward a course have influence on their performance. Some studies have reported a strong relationship between Mathematics attitude and Mathematics achievement (Minato & Yanase, 1984; Randhawa & Beamer, 1992; Schenkel, 2009; as cited by Mensah *et al*., 2013). Positive correlation between student attitude and student performance was established, and student beliefs and attitudes were found to have the potential to influence learning (Schenkel, 2009). More recently, Mensah *et al*. (2013) demonstrated positive correlation between students' attitude and students' performance, as well as teacher's attitude and students' performance in Mathematics. Indeed, attitudes play a vital role is students learning process.

Several questionnaires have been developed to assess students' attitudes, one established questionnaire relevant to this study is the Survey of Attitudes Toward Statistics: SATS-28 and SATS-36, comprising 28 and 36 items respectively. The SATS-36 was designed to assess six components of attitude towards statistics to help understand students' attitudes and how they impact teaching and learning (Schau, *et al*., 1995, Schau, 2003). In this survey, students are identified by six attributes of attitudes toward statistics: affect, cognitive competence, value, difficulty, interest and effort. The items use a 7-point Likert-type response scale

that range from 1 (strongly disagree) to 7 (strongly agree). This SATS-36 instrument represents important attitudes related to student's achievement (Elmore *et al*., 1993) and higher scores correspond to more positive attitudes (Pierce & Jameson, 2008). For its proven usefulness, SATS-36 was adopted in this study as further described in the subsequent sections.

III. RESEARCH METHODOLOGY

The scope of this study is limited to undergraduate students who enrolled for SQQS1013 Elementary Statistics course offered by School of Quantitative Sciences during the second semester session year 2014/2015 (A142). The basic problem solving techniques and some quality control concepts were employed in order to develop the new teaching approach. The former can be simplified in four steps: define the problem; generate alternative solutions; evaluate and select an alternative; implement and follow-up (ASQ, 2003). This is essentially the PDCA: Plan, Do, Check, Act, a concept popularized by Deming (Montgomery, 2013). Beginning with the end in mind (Covey, 2003) was established by setting goal and ways to achieve it. Some aspects from the eight Quality Management System (QMS) principles (Montgomery, 2013) were also employed in effective management of classroom. Among these were customer focus, leadership and teamwork, mutually beneficial supplier-customer relationship and continual improvement.

The new teaching approach also considered the feedback from the former students as well as inputs from other lecturers who have taught the course. The details of the teaching approach developed and implemented can be referred to Zain *et al*. (2017). To assess the effectiveness of the new teaching approach developed for SQQS1013 Elementary Statistics, an established questionnairre, SATS-36 was employed. A class of 54 students was selected in a pilot study to implement the new teaching approach. In addition to the SATS-36 pre-survey at the beginning of semester (Week 2), a post-survey was also conducted on this group of students at the end of the semester (Week 14). A total of 38 students completed the post-survey and their responses for both surveys were analyzed to evaluate the effectiveness of the new teaching approach.

Additionally, students' reflections through anonymous feedback via padlet.com and instructor observations were recorded throughout the semester. The scores of quizzes, mid-semester tests, assignments and final examination were used to assess the performance of the students.

IV. RESULTS AND DISCUSSION

The new teaching and learning approach was well received by the students and their final examination results were very encouraging. Impressively, about 43% of the students scored A+ and A. More importantly, none of them left blank pages (an indication of giving up) on any of the questions especially the often feared last

two chapters. Even the two students (3%) who failed the course managed to obtain more than 40% in overall marks (passing score is 50%). Apart from looking at the grades as evidence, the overall effectiveness of the new teaching approach was assessed via SATS36 surveys.

The data collected were considered as paired samples and the difference of scores (pre – post) was used in the analysis. Positive difference indicates the decline of students' attitude towards disagree, while negative value signifies the improvement of students' attitude towards agree. Based on the difference of score (score before – score after), paired sample t-test was used to identify the effectiveness of the new approach. Significant result provides evidence that the new approach was effective to change students' attitude either towards positive or negative direction.

As for overall evaluation on the effectiveness of the proposed approach, some descriptive statistics on the difference of scores is presented in Table 1.

TABLE I: DESCRIPTIVE STATISTICS ON THE DIFFERENCE SCORE (BEFORE – AFTER) FOR ALL ATTRIBUTES

SATS-36 Attributes	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Affect – students feeling concerning statistics	38	-.5614	.86603	.14049
Cognitive competence – Students attitudes about their intellectual knowledge and skills when applied to statistics	38	-.2632	1.04955	.17026
Value – students attitudes about the usefulness, relevance, and worth of statistics in personal and professional life	38	-.0088	.75408	.12233
Difficulty – students attitudes about the difficulty of statistics as a subject	38	-.2782	.66256	.10748
Interest – students level of individual interest in statistics	38	-.0329	1.12882	.18312
Effort – amount of work the student expends to learn statistics	38	.3224	1.19812	.19436

With the new approach, students attitudes improve to more positive value based on the negative mean values in all attributes, except for effort (0.3224). This reflects that the new approach did not make students improve their effort to work harder. The difference of score distribution can be clearer viewed via box-plot as displayed in Figure 1.

In general, the difference is approximately normally distributed for all six attributes with no outliers detected. The interquartile range (IQR), indicated by the length of the box shows that the difference is relatively larger for attributes 5 (interest) and 6 (effort), compared to others. Next, to assess whether or not the difference of score for each attribute is significant, paired analysis results are depicted in Table 2.

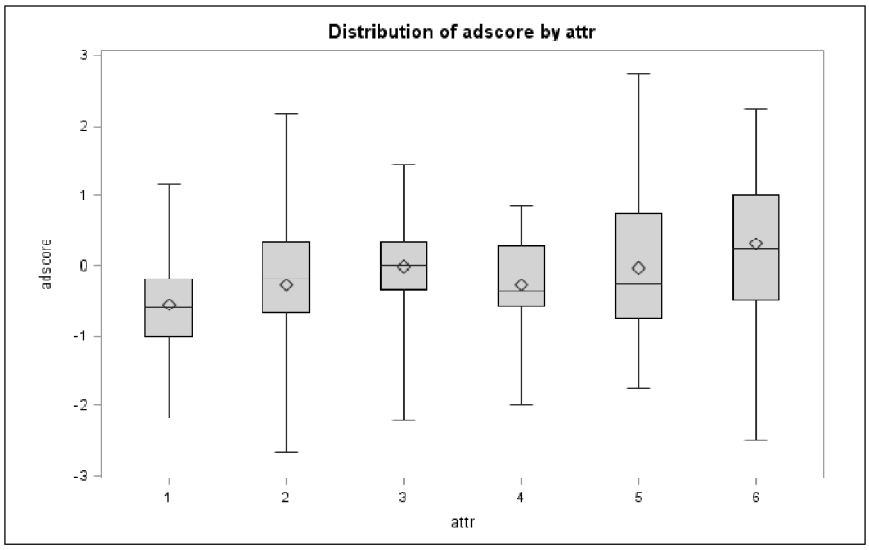

Figure 1: Box plot of the score difference before and after the implementation

TABLE II: PAIRED ANALYSIS (BEFORE-AFTER) FOR ALL SIX ATTRIBUTES.

Attribute	*Test Value = 0*					
	t	*df*	*Sig. (2-tailed)*	*Mean Difference*	*95% Confidence Interval of the Difference*	
					Lower	*Upper*
1	-3.996	37	.000***	-.56137	-.8460	-.2767
2	-1.546	37	.131	-.26317	-.6081	.0818
3	-.072	37	.943	-.00879	-.2566	.2391
4	-2.588	37	.014**	-.27820	-.4960	-.0604
5	-.180	37	.858	-.03289	-.4039	.3381
6	1.659	37	.106	.32237	-.0714	.7162

[a] ** reflect significant result at 0.05 level.

The results in Table 2 shows that attribute 1 (Affect) and attribute 4 (Difficulty) have significant difference in attitudes after the implementation of the new approach. With regards to affect, the results indicate that the new approach was effective in improving students affect or feeling towards statistics. It can be interpreted that most of the students changed their perception, and felt more comfortable in learning the course. Meanwhile, the new approach has also made students felt that the course was not actually as difficult as they thought. For further investigation, the individual items in each attribute were also analyzed as shown in Tables 3 to 8 below.

TABLE III: PAIRED SAMPLE ANALYSIS FOR EVERY QUESTION IN AFFECT – STUDENTS FEELING CONCERNING STATISTICS

Question	*p-value*	
3. I will like statistics.	0.896698	
4.* I will feel insecure when I have to do statistics problems.	0.002309	***
15.* I will get frustrated going over statistics tests in class.	0.014209	**
18.* I will be under stress during statistics class.	0.270848	
19. I will enjoy taking statistics courses.	0.142153	
28.* I am scared by statistics.	0.007209	***

Table 3 shows that items 4, 15 and 28 were statistically significant at 0.05 level. The mean differences of all these items were negative which reflect the improvement in students' attitude towards positive. Therefore the new approach was considered effective in reducing insecurity feeling of the students when they have problems, eliminating frustration over statistics test in class and increasing level of confidence.

TABLE IV: COGNITIVE COMPETENCE – STUDENTS ATTITUDES ABOUT THEIR INTELLECTUAL KNOWLEDGE AND SKILLS WHEN APPLIED TO STATISTICS

5.* I will have trouble understanding statistics because of how I think.	0.003065	***
11.* I will have no idea of what's going on in this statistics course.	0.020149	**
26.* I will make a lot of math errors in statistics.	0.457053	
31. I can learn statistics.	0.617958	
32. I will understand statistics equations.	0.299657	
35.* I will find it difficult to understand statistical concepts.	0.142937	

Cognitive competence attribute identifies students' attitudes about their intellectual knowledge and skills when applied to statistics. Even though the overall investigation of this attribute showed insignificant difference on the score (Table 1), the detailed analysis on each of the six items (Table 4) revealed that two items (5 and 11) were statistically significant. This indicates that the new approach was effective in increasing the students understanding and awareness toward this course.

TABLE V: VALUE – STUDENTS ATTITUDES ABOUT THE USEFULNESS, RELEVANCE, AND WORTH OF STATISTICS IN PERSONAL AND PROFESSIONAL LIFE

7.* Statistics is worthless.	0.805694	
9. Statistics should be a required part of my professional training.	0.145839	
10. Statistical skills will make me more employable.	0.135514	
13.* Statistics is not useful to the typical professional.	0.210776	
16.* Statistical thinking is not applicable in my life outside my job.	0.175701	
17. I use statistics in my everyday life.	0.145489	
21.* Statistics conclusions are rarely presented in everyday life.	0.856765	
25.* I will have no application for statistics in my profession.	0.836255	
33.* Statistics is irrelevant in my life.	0.040437	**

Similarly, item 33 has significant difference on the score despite showing no difference in Table 1 earlier. This finding shows that the new approach was efficient in changing the student's attitude on their feeling about the importance of statistics in their life towards positive feeling.

TABLE VI: DIFFICULTY – STUDENT ATTITUDES ABOUT THE DIFFICULTY OF STATISTICS AS A SUBJECT

6. Statistics formulas are easy to understand.	0.304925	
8.* Statistics is a complicated subject.	0.001857	***
22. Statistics is a subject quickly learned by most people.	0.318851	
24.* Learning statistics requires a great deal of discipline.	0.903232	
30.* Statistics involves massive computations.	0.031033	**
34.* Statistics is highly technical.	0.005506	***
36.* Most people have to learn a new way of thinking to do statistics.	0.822033	

As mentioned earlier in the overall analysis, there was a significant difference on the students' attitudes concerning difficulty before and after the new approach was implemented. Table 6 shows three items (8, 30 and 34) which were highly significant. These findings signify that the new approach was effective in reducing the students feeling on the complexity of statistics, making students realize that the computations are not massive and that this course is not highly technical.

TABLE VII: INTEREST – STUDENT LEVEL OF INDIVIDUAL INTEREST IN STATISTICS

12. I am interested in being able to communicate statistical information to others.	0.912187
20. I am interested in using statistics.	0.908664
23. I am interested in understanding statistical information.	0.73053
29. I am interested in learning statistics.	1

Table 7 shows no significant difference on the score of student's attitude concerning interest before and after the new approach implemented. There is no evidence to suggest that the new approach was effective to increase student's level of interest in statistics.

TABLE VIII: EFFORT – AMOUNT OF WORK THE STUDENT EXPENDS TO LEARN STATISTICS

1. I plan to complete all of my statistics assignments.	0.08817	*
2. I plan to work hard in my statistics course.	0.16182	
14. I plan to study hard for every statistics test.	0.18107	
27. I plan to attend every statistics class session.	0.35227	

Concerning the attribute Effort, Table 8 shows that the implementation of the new approach did not have much impact on the students' effort, where none of the

items was significantly different at level of 5% or lower; only item 1 showed a significant difference at 10%.

V. CONCLUSION

The new teaching approach was effective in improving overall affect: students' feelings about statistics. Students felt more comfortable in class, and the teaching and learning process became more interactive. Their anxieties towards statistics were also reduced when they realized that the calculations were not very complicated. This enhanced the students' confidence and reduced their frustration over quizzes and tests in class. The new approach was also found to improve two of the cognitive items: increase students understanding and awareness towards this course. With regards to difficulty attribute, students finally realized at the end of semester that the course was not as difficult as they thought earlier (in the beginning of semester). Students with more positives attitudes on difficulty attribute tend to perform better in the course. A student-centered learning approach with daily motivation and continuous quality improvement efforts is able to change the attitudes of students towards statistics, hence, improving their performance in elementary statistics course.

Acknowledgement

The authors acknowledge and thank Prof. Candace Schau of CS Consultants for the permission to use the SATS-36 in this study. Gratitude goes to the students and lecturers involved in the study during semester A142, University Teaching Learning Centre (UUM UTLC) and last but not least, Universiti Utara Malaysia for awarding us with the Scholarship of Teaching and Learning (SoTL) grant (SO Code: 13015) to carry out this research project.

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