Influence of self-efficacy and attitudes towards statistics on undergraduates’ statistics engagement in a Malaysian public university

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Abstract. Undergraduate students’ statistics engagement plays a vital role in their performance in introductory statistics courses. Self-efficacy and attitudes towards statistics were claimed to influence students’ engagement. Accordingly, this study investigated the influence of self-efficacy and attitudes towards statistics on undergraduate students’ statistics engagement in a Malaysian public university. This study was conducted on first year students from various fields of study enrolled in an introductory statistics course. A random sample of 293 students were selected to participate in the survey. Descriptive analysis revealed that both students’ statistics engagement and self-efficacy were moderate, while their attitudes towards statistics were positive. Correlation analysis indicated that statistics engagement was significantly related to self-efficacy and attitudes towards statistics. Furthermore, multiple linear regression analysis showed that self-efficacy and attitudes towards statistics are significant predictors of statistics engagement and explained half of its’ variation. Attitudes towards statistics had a greater influence on statistics engagement than self-efficacy for these students. These findings affirmed that self-efficacy and attitudes towards statistics influenced students’ statistics engagement. In essence, having high self-efficacy and positive attitudes towards statistics will help students to be highly engaged in their learning to perform better in statistics course.

1. Introduction

In recent years, teaching-learning process of statistics for undergraduate students has become a global concern. The emergence of data-centric world has changed the role of statistics and data immensely. As a precursor to data science, introductory statistics has become an important course amongst others to be offered to students hailing from a variety of academic fields. These courses also serve as the primary platform to equip students with adequate statistical knowledge and data analytics skills [1, 2, 3]. Similarly in Malaysian public universities, at least one introductory statistics course has been made compulsory for first year students. Apparently, novice students undertaking the course seemed to fail in grasping the required statistical knowledges effectively [4].

There can be various reasons behind students’ incompetent performance. Some well identified factors include instruction methods, lack of reasonable background in mathematics, students’ interests, feelings, beliefs, expectations, motivations and engagement [5]. Of all these factors, students’ engagement in statistics learning has been highlighted as a prominent cause for their
unsatisfactory performance [4]. Accordingly, various researchers have reported that students were found to be highly disengaged in their learning of statistics [4, 5, 6]. High rate of disengagement among students indicated clearly that students were somewhat under pressure to undertake the course and thus, the learning process becomes meaningless as there was no individual interest exhibited. As such, they would right away consider it as a burden and irrelevant knowledge to be learnt [1].

Students' statistics engagement is formally defined as the quality of students’ efforts involved in learning of statistics that play an important part for obtaining desired outcomes from the learning process [7, 8, 9]. Engagement is a multi-faceted construct involving students’ emotion, behaviour and cognition aspects pertinent to statistics [10]. Cognitive engagement encompasses students’ willpower to go beyond the common level to master advanced skills in statistics learning [11, 12]. Affective engagement comprises students’ favourable or unfavourable reactions towards instructors and peers [11, 12]. Behaviour engagement involves students’ participation in statistics learning tasks; and favourable conduct and positive behaviours in the learning process [11, 12]. Engagement is deemed to be a crucial aspect in students’ learning process as it holds a significant relationship with students’ achievement, performance, learning outcomes, resilience, attainment and their attendance, adherence and retention in statistics classroom [13, 14, 15, 16, 17, 18, 19, 20].

Self-efficacy is viewed as personal judgements on individual capabilities that influence and reshape students’ behaviour to accomplish their goals in academic pursuit [21]. Self-efficacy theory states that the cooperative interaction between students’ personal thoughts and the nature of task assigned to them would decide their behaviour type and their success rate [22]. In general, students’ self-efficacy is driven by four factors, i.e. mastery experiences, vicarious experiences, social persuasion and physiological states [23]. The major contributor of self-efficacy is mastery experiences which deal with students’ own experiences on a subject matter [24]. Vicarious experiences are based on what students perceive and observe when their peers are performing a task, which helps them to manipulate their previous experiences as a result of new observations [23, 25]. Social persuasion is concerned about how an impeccable student becomes an exemplary for his/her peers [26]. Physiological states such as stress, anxiety and mood swings do control students’ performance (success or failure), in which self-efficacy may become lower after they have experienced those gloomy emotions and uncertainty about their abilities [27]. Recently, self-efficacy has been given high regards in educational research at many levels for a wide variety of academic fields (including statistics), particularly in the context of academic motivation [28].

Attitudes towards statistics are commonly defined as a multidimensional concept representing students’ tendency to respond positively or negatively to the learning aspects of statistics [29]. It involves attributes related to emotions and motivations; beliefs and knowledge; and behaviour in statistics learning process [30]. Generally, attitudes towards statistics consist of four dimensions viz. affect (students’ feelings about statistics); cognitive competence (students’ attitude about their intellectual knowledge and skills when applied to statistics); value (students’ attitude in regards to the usefulness, relevance, and worth of statistics); and difficulty (students’ attitude about the difficulty of learning statistics) [31]. According to Vanhoof, Kuppens, Sotos, Verschaffel and Onghena [32], attitudes towards statistics are claimed to primarily influence statistics teaching-learning ecosystem and students’ performance in statistics courses. Moreover, Mills [31] indicated that attitudes play a significant role in the context of introductory statistics courses. Emmioglu and Capa-Aydin [33] asserted that it is imperative for students to possess positive attitudes towards statistics through several measures such as believing their ability in understanding and using statistics; perceiving that statistics is useful and interesting; ready to invest extra efforts to learn statistics; and believing that statistics is not too difficult to learn [33, 34].
Students’ self-efficacy, attitudes, impressions, perceptions, interests, feelings, and beliefs are propounded to have direct effect on students’ engagement in learning of statistics [35, 36]. Several studies claimed that among the known factors, students’ self-efficacy and attitudes towards statistics are most positively related to students’ statistics engagement [37, 38, 39]. Low self-efficacy and negative attitudes are identified as primary obstacles for effective engagement and learning and have been reported to become extensive lately [40]. Hence, appropriate attention has to be given to aspects of self-efficacy and attitudes towards statistics in regards to students’ statistics engagement [41]. In view of the above discussion, the objective of this study is to investigate the influence of self-efficacy and attitudes towards statistics on undergraduates’ statistics engagement in a Malaysian public university.

2. Methodology
A descriptive correlational survey design was employed on first year students enrolled in various fields of study (non-mathematics oriented programmes) taking an introductory statistics course during the first semester in 2016/2017 session. From a total of 600 students attending the course, 293 students were randomly selected to participate in the survey that consisted of questionnaires pertaining to statistics engagement, self-efficacy and attitudes towards statistics.

Students’ statistics engagement was measured using 54 questionnaire items adapted from the National Survey of Student Engagement (NSSE) instrument encompassing the three domains of engagement viz. affective (22 items), cognitive (20 items), and behavioural (12 items) [42]. Statistics engagement was evaluated based on students’ participation and effort; positive affect and course belonging; and course values respectively [43]. Self-efficacy was assessed using 22 questionnaire items adapted from the Mathematics Self-Efficacy Scale (SMES) by Lent, Lopez and Bieschke [44]. Items for self-efficacy were constructed based on the elements of personal performances, peer modelling, social persuasion and perceived physiological and effective states accordingly [45]. Attitudes towards statistics were measured using 28 items adapted from the Survey of Attitudes Toward Statistics-28 (SATS-28) by Schau, Stevens, Dauphinee and Vecchio [46]. Students’ attitudes towards statistics were assessed based on positive and negative emotions as well as feelings encountered by students enrolled in the course [47]. These particular instruments were chosen because they comprised important attributes of engagement, self-efficacy and attitudes pertinent to students’ performance and achievement.

Some adjustments to the original instruments were made to suit the respondents and the relevance to local academia context. Respondents were asked to state their agreement and disagreement towards the self-efficacy questionnaire items using four-point Likert scale viz. (1): Strongly Disagree, (2): Disagree, (3): Agree and (4): Strongly Agree. Whereas, for statistics engagement and attitudes towards statistics, five-point Likert scale was used with the degree of agreeableness indicated by (1): Strongly Disagree, (2): Disagree, (3): Unsure and (4): Agree and (5): Strongly Agree. A pilot study was conducted using 25 randomly selected students undertaking this course. The internal consistency of these instruments (given in Table 1) was found to be reliable and valid based on Hair, Black, Babinand, Anderson and Tatham [48].

Mean score (M) was used to summarise and quantify students’ responses from the questionnaire. Statistics engagement and self-efficacy were classified as high if $M > 3.68$, moderate if $2.34 \leq M \leq 3.68$ and low if $M < 2.34$. This classification was accomplished by dividing the range of mean scores into three classes. Attitudes towards statistics were interpreted as positive if $M > 2.50$ and negative if $M \leq 2.50$. The cut-off point for distinguishing positive and negative attitudes was assigned using the basis of half from the maximum possible mean score. Questionnaire items that were negatively formulated were reverse coded in the analysis without changing the original statements to ensure that a high mean score corresponds to a positive response.
Table 1. Cronbach’s alpha values of the instruments.

| Statistics engagement | Affective | 0.81 |
|-----------------------|-----------|------|
|                       | Cognitive | 0.71 |
|                       | Behaviour | 0.87 |
|                       | Overall   | 0.89 |
| Self-efficacy         |           | 0.79 |
| Attitudes towards statistics |       | 0.79 |

3. Results
Demographic information of respondents is displayed in Table 2. Respondents consisted of 44 males (15.0%) and 249 females (85.0%). Majority of them were Malay (73.7%), followed by Chinese (20.5%), Indian (3.4%) and other ethnics (2.4%). About 46.4% respondents were students from Faculty of Human Ecology, 19.5% from Faculty of Economics & Management, 14.0% from Faculty of Environmental Studies, 13.0% from Faculty of Food Science & Technology, 4.4% from Faculty of Educational Studies, 1.4% from Faculty of Biotechnology & Biomolecular Sciences, 0.7% from Faculty of Forestry and 0.3% from Faculty of Agriculture respectively.

Table 2. Demographic information of respondents.

| Frequency | Percent(%) |
|-----------|------------|
| Gender    |            |
| Male      | 44         | 15.0 |
| Female    | 249        | 85.0 |
| Ethnicity |            |
| Malay     | 216        | 73.7 |
| Chinese   | 60         | 20.5 |
| Indian    | 10         | 3.4  |
| Others    | 7          | 2.4  |
| Faculty   |            |
| Agriculture | 1      | 0.3  |
| Forestry  | 2          | 0.7  |
| Economics & Management | 57 | 19.5 |
| Educational Studies | 13 | 4.4  |
| Food Science & Technology | 38 | 13.0 |
| Human Ecology | 136 | 46.4 |
| Biotechnology & Biomolecular Sciences | 4 | 1.4 |
| Environmental Studies | 41 | 14.0 |

Mean scores (M) and corresponding standard deviations (SD) for statistics engagement, self-efficacy and attitudes towards statistics are presented in Table 3. The overall mean score for statistics engagement was 3.38 (SD = 0.24) indicating that students’ engagement level was moderate. Similarly, inspection on individual domains of statistics engagement clarified that students conformed to moderate level of statistics engagement, as their mean scores fall within the moderate range. Students scored the highest on behaviour domain (M = 3.63, SD = 0.52), followed by affective domain (M = 3.35, SD = 0.41) and cognitive domain (M = 3.26, SD =
0.35). Inspection on the individual questionnaires items for statistics engagement revealed that students were keen in learning contemporary statistical concepts and techniques as well as agreed that learning of statistics was an interesting process (behaviour engagement). Furthermore, students also agreed that obtaining good results in statistics tests was a rewarding pursuit although statistics was not an easy course (affective engagement). In the meantime, they were likewise on edge about getting unsatisfactory results for tests. Besides, they also concurred that it was useful to memorise statistical techniques especially in solving word problems that involves computations (cognitive engagement). On the flip side, most students admitted that they did not make a decent attempt to solve difficult problems which might have required extra mathematical background. In like manner, they conceded that they did not endeavour more than once for a difficult problem, even if the first solution was incorrect. Consequently, they were apprehensive when unable to solve the given problems. Students’ efforts in solving statistical problem may appear low due to the nature of problems given to them, i.e. textbook based problems that could not be related to real life scenarios. Rumsey [49] stated that students will be more captivated and engaged in classroom when they are exposed to application of proper statistics in real life problems. Exposure to real life problems in the classroom would help to cultivate students’ interest in solving it, and eventually double up their efforts.

Students’ self-efficacy was also found to be moderate with a mean score of 3.68 (SD = 0.24). Based on the responses, it was found that most students were stressful in statistics classroom. Due to their stress, they seldom ask questions during the lecture. Accordingly, students claimed that they were tensed up while solving difficult problems. Facing such tensions would imperil their self-confidence which later affect their action and focus in classroom. According to Margolis and McCabe [50], such implication is known as statistical avoidance, which is frequently resulted from negative attitudes and affective reactions in regards to learning of statistics. Similarly, Suinn and Winston [51] expressed that tension and anxiety faced by students often interfere with their solving of statistical problems and number manipulation problems in a wide variety of situations. Schunk, Meece and Pintrich [41] stated that students’ self-efficacy tended to diminish as they progress from school to university level, usually caused by several reasons such as higher competition, more standard evaluation practices, minimal attention from instructors and increased stress.

Students exhibited positive attitudes towards statistics with a mean score of 3.07 (SD = 0.46). The responses indicated that students highly agreed that discipline is a key requirement for learning of statistics. Besides that, they were optimistic in solving standard statistical problems, indicating that they had put in a great effort in building their analytical skills. Furthermore, students felt tackling statistical problems was rather an evolving skill than simply a confined list of instructions, implying they were proactive and innovative in their learning. Nevertheless, students also perceived statistics as a difficult course due to the presence of long calculation mechanisms and as well as their high tendency in making calculation errors. This could be because of their poor mathematical background. Garcia-Santillan, Venegas-Martinez and Escalera-Chavez [52]; and Suanpang, Petocz and Kalceff [53] stated that the prominent attribute of students from non-mathematics oriented programmes concerning their attitudes towards statistics was indeed the difficulty faced with the mathematical components in the courses.

Table 4 displays the Pearson correlation coefficients employed to measure the association between statistics engagement and self-efficacy; and between statistics engagement and attitudes towards statistics. There was a significant relationship between students’ statistics engagement and students’ self-efficacy ($r = 0.53^\ast, p < 0.05$). In addition to that, each domains of statistics engagement were also positively related with self-efficacy as indicated by the correlation coefficients for affective ($r = 0.50^\ast, p < 0.05$), cognitive ($r = 0.42^\ast, p < 0.05$) and behaviour ($r = 0.46^\ast, p < 0.05$). Similarly, students’ statistics engagement was positively related with attitudes
Table 3. Mean score and standard deviation values.

| Mean (M) | Standard Deviation (SD) |
|----------|-------------------------|
| Statistics engagement | Affective | 3.35 | 0.41 |
| | Cognitive | 3.26 | 0.35 |
| | Behaviour | 3.63 | 0.52 |
| | Overall | 3.38 | 0.36 |
| Self-efficacy | 3.68 | 0.24 |
| Attitudes towards statistics | 3.07 | 0.46 |

towards statistics ($r = 0.70^*, p < 0.05$). Furthermore, individual domains of engagement were significantly related to attitudes towards statistics with correlation coefficients for affective ($r = 0.74^*, p < 0.05$), cognitive ($r = 0.50^*, p < 0.05$) and behaviour ($r = 0.51^*, p < 0.05$).

Table 4. Pearson correlation coefficients.

| Statistics engagement | Self-efficacy | Attitudes towards statistics |
|-----------------------|---------------|-----------------------------|
| Affective             | 0.50*         | 0.74*                       |
| Cognitive             | 0.42*         | 0.50*                       |
| Behaviour             | 0.46*         | 0.51*                       |
| Overall               | 0.53*         | 0.70*                       |

* Significant at 5% level.

Further, in order to determine if self-efficacy and attitudes towards statistics were able to predict students’ statistics engagement, multiple linear regression analysis using stepwise method was employed. Statistics engagement was the dependent variable with self-efficacy and attitudes towards statistics as independent variables (predictors) in the regression model. The full model (both predictors included in the model) summary of the fitted regression model is presented in Table 5. The multiple correlation coefficient ($R$) value of 0.71 indicated a high degree of correlation between the observed and predicted values of statistics engagement, while the multiple coefficient of determination ($R^2$) value revealed that 50% of total variation in statistics engagement can be explained by self-efficacy and attitudes towards statistics.

Table 5. Model summary.

| R        | R Square | Adjusted R Square | Std. Error of the Estimate |
|----------|----------|-------------------|---------------------------|
| 0.71     | 0.50     | 0.50              | 0.25                      |

Summary of analysis of variance (ANOVA) corresponding to the fitted regression model is provided in Table 6. Self-efficacy and attitudes towards statistics employed in the regression model were significant predictors of students’ statistics engagement, as evidenced by the test statistic $F(2, 290) = 145.34$ with $p < 0.05$. 

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Table 6. ANOVA.

| Model       | Sum of Squares | df  | Mean Square | F    | Sig. |
|-------------|----------------|-----|-------------|------|------|
| Regression  | 18.61          | 2   | 9.30        | 145.34 | 0.00 |
| Residual    | 18.56          | 290 | 0.06        |       |      |
| Total       | 37.17          | 292 |             |       |      |

Table 7. Coefficients.

| Coefficients | Unstandardized (B) | Standardized (Beta) | t     | Sig. |
|--------------|--------------------|---------------------|-------|------|
| (Constant)   | 1.12               | 4.74                | 0.00  |      |
| Self-efficacy| 0.23               | 0.15                | 2.78  | 0.01 |
| Attitudes towards statistics | 0.47               | 0.60                | 11.18 | 0.00 |

4. Conclusions
The aim of this paper was to investigate the influence of self-efficacy and attitudes towards statistics on statistics engagement among undergraduate students in a public university in Malaysia. Based on the correlation coefficients, it can be asserted that statistics engagement was positively related to both self-efficacy and attitudes towards statistics. Multiple linear regression analysis showed that self-efficacy and attitudes towards statistics were equally significant factors to predict statistics engagement. Approximately 50% of the variance in statistics engagement was accounted for by self-efficacy and attitudes towards statistics. Hence, changes in students’ self-efficacy and attitudes towards statistics can explain the changes in their statistics engagement. Finally, it can be affirmed that self-efficacy and attitudes towards statistics influenced students’ statistics engagement. In particular, students’ behaviour engagement was highly influenced by self-efficacy and attitudes towards statistics, followed by their affective and cognitive engagements. These findings were also in accordance to previous studies by [19, 36, 54]. Between self-efficacy and attitudes towards statistics, the latter had a greater influence on statistics engagement for these students.

Findings from descriptive analysis indicated that students’ self-efficacy was at moderate level. Students’ beliefs on their capability to learn statistics and to perform any task related to their learning of statistics are undeniably influenced by the elements of self-efficacy. For instance, an introductory statistics course would be taught to students from different backgrounds and as such, most students’ self-efficacy towards statistics is easily affected due to the difference
in their mastery level or experience in statistics. Students may be affected by personal and situational effects throughout the course which would influence their performance level; however self-efficacy will naturally increase when students perceive they are performing well. Accordingly, Jackson [22]; Chowdury and Shahabuddin [40]; and Margolis and McCabe [50] suggested that the probability of active statistics engagement will be higher among students who discern themselves capable to learn statistics compared to those who feels incompetent. Students need to understand that minimal success rate or slow progress in the course will not inevitably lower their self-efficacy as long as they believe that their performance can always be improved with additional efforts and applying more effective learning strategies [41]. On the flip side, students’ attitudes towards statistics were found to be positive. Overall, students had positive feelings about statistics; positive attitude about their intellectual knowledge and skills when applied to statistics; positive attitude regarding the usefulness, relevance, and worth of statistics in personal and professional life; and positive attitude on difficulty of statistics as a course. This further implied that students tended to appreciate the relevancy of statistics and perceived it as an applicable and useful knowledge in real life as well as an important requirement for their future professions. In summary, most students realised what statistics is capable of and is essentially a part of their daily life.

The key issue of concern discovered in this study was students’ statistics engagement was moderate. Students’ statistics engagement level has to be raised so as to ensure them to effectively acquire statistical knowledge and skills [16]. It has to be noted that although students’ attitudes towards statistics were positive yet their statistics engagement level was still moderate due to the influence of moderate self-efficacy. Hence, imparting both high self-efficacy and positive attitudes towards statistics are equally important to promote higher statistics engagement. Several strategies can be applied to the existing instruction methods in universities to ensure students to become more self-efficacious and to consistently exhibit positive attitudes towards statistics. One such strategy include practical teaching-learning approach which makes the learning realistic, relevant and interesting compared to the conventional instruction methods which rely primarily on textbooks and lectures. Rumsey [49] and Carnell [55] proposed an approach in which students will collect their own data and analyse the data by applying the statistical techniques taught as well as interpret their results. Such approach is certainly practical and appropriate in relative to just instructing students to work out on textbook problems. Implementation of such strategies coupled with the conventional instruction methods, would foster higher self-efficacy and positive attitudes towards statistics [8, 54, 55]. In a nutshell, promoting higher self-efficacy and cultivating consistent positive attitudes towards statistics would strengthen students’ statistics engagement in introductory statistics courses.

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