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Retraction

Retracted: Arab and Malay Students' Attitudes toward Statistics and Their Learning Styles: A Rasch Measurement Approach

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] A. Fayomi, Z. Mahmud, A. Algarni, and A. M. Almarashi, "Arab and Malay Students' Attitudes toward Statistics and Their Learning Styles: A Rasch Measurement Approach," *Mathematical Problems in Engineering*, vol. 2022, Article ID 4144254, 10 pages, 2022.

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Research Article

Arab and Malay Students' Attitudes toward Statistics and Their Learning Styles: A Rasch Measurement Approach

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Students' learning of statistics has been studied from a variety of angles, and this study is no different. The main purpose is to compare the Malay and Arab students' attitudes toward learning statistics and their learning styles in understanding statistics. A survey questionnaire and face-to-face interview techniques were used to elicit information from 150 students based on the cohort. They were asked about how they learn to solve statistical problems based on Kolb's four learning cycles: feeling, reflective observation, thinking, and doing. Attitude responses were numerically recorded based on a five-point Likert scale, while preference for learning styles was recorded as 1 (Do and Feel) or 0 (Watch and Think). Both attitude and learning style data were combined and subjected to Rasch analysis. Results show that a majority of the Arab and Malay students have moderate to high positive attitude toward learning statistics. Generally, students from both cultures are classified as the "Accommodating" type with a preference for doing and feeling from the experience of doing statistical problems. Arab students are classified as the "Assimilating" type with a preference for thinking, reflecting, and learning from observation, while Malay students are classified as the "Converging" type with a preference for thinking and doing statistical exercises.

1. Introduction

Statistics researchers and educators have performed several studies on students' attitudes toward statistics and their influence on their statistical learning [1–3]. Despite the focus on the relevance of statistics, students continue to struggle with understanding them. The study in [4] said that the targeted outcomes of basic statistics courses should include students' competence and conviction in their capacity to master statistical skills and use them in a real-world situation.

But while knowing the importance of being able to statistically think, many students in the social sciences, arts, and management sciences cannot exhibit this ability. Some people are hesitant to learn statistics because they are afraid of numbers and formulae, even if they are aware of the relevance and necessity of its usage later [5]. Student awareness of their statistical thinking handicap [6] or the degree of their statistical literacy is key to ensuring that they are aware of their statistical thinking level and understanding. This knowledge would allow them to develop the necessary statistical abilities, tools, and information.

In higher education, the potential instructional information regarding students' learning styles has been highlighted. The study in [7] found that "there are obvious connections between how an individual conceptualizes learning, the methods through which the individual strives to learn, and the consequences of the individual's attempts to learn" [8]. Learning style choices have an influence on how students respond to educational programs or curricula in terms of comprehending their goals and objectives. According to [9], students may be better equipped to adapt to diverse settings if they are aware of their learning styles. The study in [10] separated learning styles into three interconnected components: information processing, instructional preferences, and learning methods. When it

comes to learning approaches, the work in [11] argues that pupils who are familiar with a range of tactics are more likely to pick the right one.

Your cultural background might also influence your learning style. An individual's cultural background may also be influenced based on learning styles. According to [12], learning methods related to diverse cultural backgrounds have a role in maximizing academic success; high achievers report using more strategies than lesser achievers [13], but these strategies may vary among students [14]. The study in [15] found that persons in nations with high levels of gender equality, in-group collectivism, and institutional collectivism are likely to have a more abstract learning style. This is confirmed further by [16–18], who demonstrated that learners' beliefs about their chances of success are influenced by the learning techniques they employ.

Even considerable research has been conducted to explore cultural variations across nations [19], and cultural differences in thinking and learning statistics have received less attention. This study will look into how students from the Arab and Malay cultures understand statistical concepts. Kolb's learning type model, which is based on four learning cycles, namely, feeling-concrete experience (CE), watching-reflective observation (RO), thinking-abstract conceptualization (AC), and doing-active experimentation (AE), will be used to assist learning style identification (AE). This study investigates students of Arab and Malay cultures' attitudes about studying statistics and learning methods.

The main purpose is to compare the Malay and Arab students' attitudes toward learning statistics and their learning styles in understanding statistics.

The following are the objectives of the study:

(1) To describe whether students of Arab and Malay cultures differ in their perceived attitude toward learning statistics

(2) To describe whether students of Arab and Malay cultures show similar or different learning styles in learning statistics

(3) To compare certain attitudes of Arab and Malay students based on item characteristic curves

2. Attitude toward Statistics

Egyptian instructors enrolled in an introductory statistics course utilized the Survey of Attitudes Toward Statistics (SATS) to examine the relationship between attitudes toward statistics, anxiety, mathematical talent, and statistics achievement. The instructors' statistical success was evaluated using ten open-ended questions that included descriptive and inferential statistics. According to the findings of the study, instructors in Egypt have a minor beneficial influence on attitudes toward statistics on the statistical success [20]. Another study [21] concentrated on four major components to define instructors' views about statistics: affect, cognitive competency, value, and challenge. Based on the SATS, the study looked at 367 preservice teachers at the Faculty of Education, University of Lleida, Spain, and their attitudes about statistics, anxiety, mathematical ability, and statistics success. The SATS questionnaire, which consisted of 28 items on a five-point Likert scale (from 1 "Strongly Disagree" to 5 "Strongly Agree"), was utilized in the study. According to the findings of the survey, participants regard statistics as little challenging, with small respect for the utility and significance of the statistics. Their personal and professional lives are also heavily influenced by statistics. They also have a positive attitude toward statistics education.

There were significant differences between current and future elementary school teachers' perceptions of statistics [22]. Instructors were evaluated based on their gender, a number of prior statistics courses, specialization (the topic that the teacher teaches), and teaching experience using the EAEE scale instrument. EAEE is a mixture of the Statistics Attitude Survey (SAS) [23], the Attitudes Toward Statistics (ATS) [24], and the Spanish scale [25], with 25 items that include both positive and negative items to prevent acquiescence bias. The EAEE instrument includes a five-point Likert scale ranging from 1-"Strongly Disagree," through 3-"Neutral," to 5-"Strongly Agree," on which respondents must indicate their degree of agreement or disagreement with the items.

The study indicated that older instructors exclude statistical subjects from their instruction as compared to younger teachers because they find the subject difficult to teach. Furthermore, instructors who have a negative attitude toward statistics do not use statistics in their professional activities.

In this study, the SATS scales were modified in the survey instrument to assess students of Arab and Malay cultures' attitudes toward statistics learning. Many studies on how students learn statistics have been conducted in a variety of domains and cognitive elements of learning [26, 27]. Students start learning processes with varying goals and preferences, which allow them to attain satisfying learning results via several learning routes [28].

Understanding statistical principles is the foundation for understanding statistics. Numerous studies on statistical reasoning (e.g., on variation and sample distributions) have shed light on how students learn to use statistical reasoning [28–31]. Statistical literacy, statistical reasoning, and statistical thinking are increasingly recognized as three separate but related cognitive processes in statistics education research today. It is possible to have a certain level of literacy, logic, and reasoning even before formal statistics schooling [32].

Reference [33] used statistical reasoning assessment (SRA) to evaluate students' reasoning ability on probability subjects. Statistics concept inventory (SCI), on the other hand, was created to test engineering students' statistics comprehension [34]. In their Assessment Resource Tools for Improving Statistical Thinking (ARTIST) initiative, [35] designed an online test called Comprehensive Assessment of Outcomes in Statistics (CAOS). In basic statistics classes, CAOS aims to test students' understanding of statistical concepts.

This study, on the other hand, took a different approach by incorporating Kolb's learning model into statistics to identify students' learning styles based on four learning

cycles, in which Kolb relates abstract conceptualization (thinking) to concrete experience (feeling) and reflective observation (watching) to active experimentation (doing). Figure 1 depicts one such case. Individuals' learning styles may be determined using the two-by-two matrix view. For example, a person with a dominant learning style of "doing" rather than "watching" the task and "feeling" rather than "thinking" about the experience will have a learning style that combines and represents those processes, namely, an "Accommodating" learning style.

3. Methods

A survey was conducted on a total of 150 undergraduate students who enrolled in a statistics subject at a public university in Selangor, Malaysia, and a public university in Jeddah, Saudi Arabia. The students were from various backgrounds of studies and were taught by statistics lecturers in the respective countries. The investigation only focused on a selected cohort and measured the students' attitude and their styles in learning statistics at their respective universities. They were interviewed after the tenth week of learning the subject.

4. Instruments

In this investigation, two types of equipment were used. The first tool was a questionnaire on people's attitudes about statistics learning. It comprised of 28 items that assessed students' perceived attitudes toward learning probability concepts on a five-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The attitude questions about statistics were modified from the Student's Attitude Towards Learning Statistics questionnaire [36] and the Survey of Attitudes Toward Statistics (SATS) scale [37]. Based on the students' learning environment, the original conceptions of SATS and the Student's Attitude Towards Learning Statistics questionnaire were updated. Figure 2 depicts the tool used to assess students' attitudes about learning statistics.

As for the second instrument, it was based on Kolb's learning style model, which was used to evaluate students' learning styles in statistics classes (Figure 3).

Figure 3 shows Kolb's learning model chart that was used in this study, based on the student's responses to Kolb's learning chart and the following questions:

(i) How do you begin a task?

(ii) How have you emotionally reacted to the experience?

The replies of the students were tallied and classified based on four potential combinations, namely, watch-think, watch-feel, do-think, and do-feel [38]. As stated in Table 1, the combination would be cross-tabulated depending on each student's response.

A majority of the students (47%) prefer to think through while learning a new topic in the class and then learn by doing the exercise or solving the problems later. About 30% initially prefer to watch and think through the lessons instead of doing it. Based on Kolb's learning model, those students were categorized as having "converging" and "assimilating" characteristics, respectively.

5. Rasch Measurement Model

All data gathered from the instruments were subjected to Rasch measurement using Winsteps 3.90.2. Rasch rating scale and Rasch dichotomous models were used in the analysis of data gathered from the questionnaire. A person's logit score may, therefore, be used to assess a person's ability, and an item's logit score can be used to evaluate the difficulty of an item. Because a person's competence is defined by the proportion of correct answers and an item's difficulty is determined by the proportion of incorrect answers, both estimations are connected and may be mathematically expressed, i.e., the Rasch dichotomous measurement model, as follows:

$$x_{ni} = \left(\frac{1}{B_n}, D_i\right) = \frac{e^{B_n - D_i}}{1 + e^{B_n - D_i}}. \quad (1)$$

A Rasch model analysis determines how well the data match the Rasch model. It considers two parameters: the complexity of the test item and the person's aptitude. By examining the gap between the two parameters, it is believed that these parameters are interdependent. A probabilistic technique is used to achieve the separation, in which a person's raw test result is transformed into a success-to-failure ratio and subsequently into logarithmic chances that the individual would properly answer the items. A logit scale is used to depict this, and it may be displayed on a single scale ruler.

The model expresses the likelihood of getting the right response (1 rather than 0) as a function of the amount of the difference between the person's ability (Bn) and the item's difficulty (Di) (i). The Rasch model is used to compute a person's skills and item difficulties and then plot the person's abilities and item difficulties on the same scale. The model states that the likelihood of a person succeeding on a particular item is an exponential function of the gap between that person's aptitude and the difficulty of the item [39].

The Rasch model gives two sorts of indicators to assist researchers in determining whether there is sufficient item spread and sufficient spreadability among individuals. The person dependability index reflects the likelihood of replicability of the person ordering if the sample individuals were given a different set of items measuring the same construct [40]. It also necessitates a wide enough range of skills throughout the sample. People with more of the trait of interest should be given a higher score [41]. In analyzing data quality, infit and outfit mean square fit statistics are used to see whether answers deviate from what the Rasch model predicts for each item and person. A substantial number of unexpected replies are indicated by high mean square fit statistics. High person mean square scores suggest that test takers who filled in replies at random had exceptional knowledge gaps. Item infit

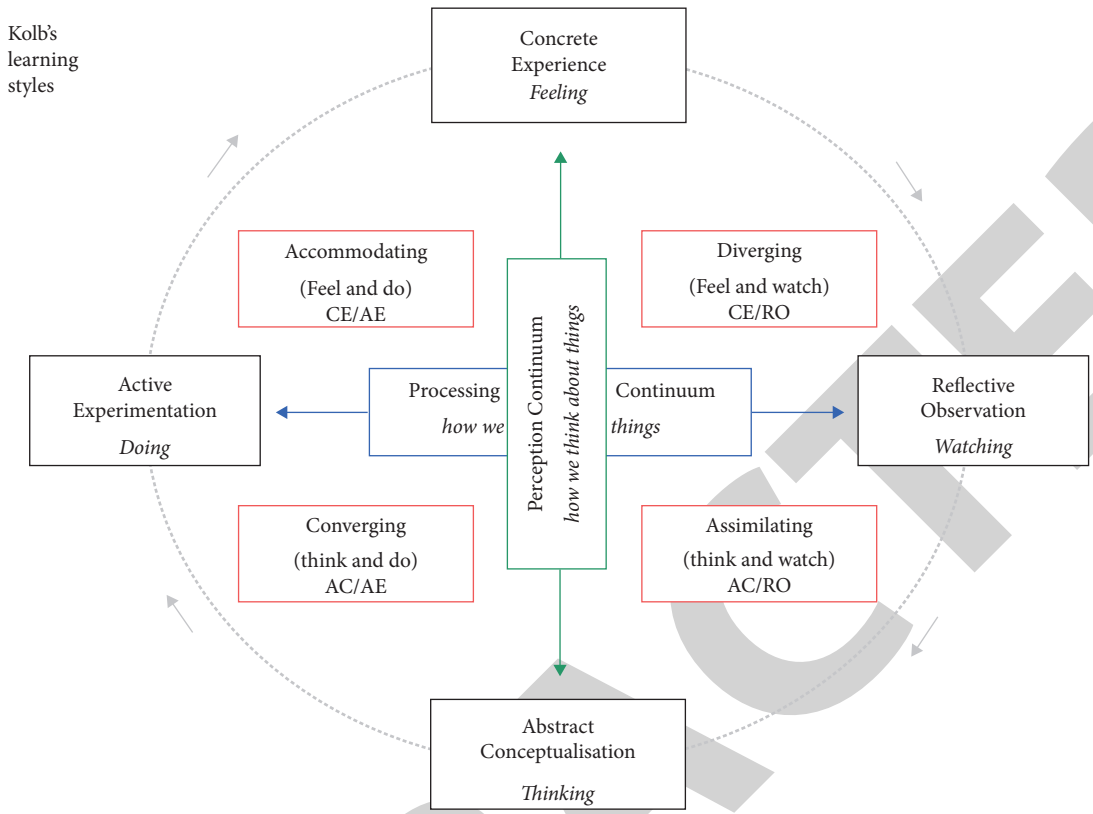


Figure 1: Kolb's learning style model.

mean square values between 1.5 and 2.0 are deemed unproductive for measurement, whereas values more than 2.0 are regarded as deteriorating [40].

The Rasch measurement seeks to achieve generalizability while avoiding bias due to characteristics such as gender and race. A Rasch analysis calculates the anticipated value of an item for people of the same skill level. These projected values may then be compared to observed values for various groups of people (for example, men and women, or different groups of classes).

5.1. Wright Map. The Wright map displays the distribution of person measure (left side of logit ruler) and item measure (right side of logit ruler) based on the polytomous Rasch model. When a higher person logit is calibrated against a lower item logit, the probability that the person has a positive attitude toward learning statistics is at least 0.5. The probability is less than 0.5 if a lower person logit is calibrated against a higher item logit.

6. Data Structure in Rasch Measurement

Data structure for Rasch analysis includes data preparation in Excel format as in formatted text (space delimited). It was then transformed to Winsteps 3.90.2 __.prn file that was used to execute the necessary Rasch outputs. Extract of the Excel data structure of the questionnaire items and __.prn file are shown in Figures 4 and 5, respectively. ____.prn file in Figure 5 is the base Winsteps program used to execute the necessary Winsteps outputs.

7. Results and Discussion

7.1. Objective 1 and Objective 2. The Wright map in Figure 6 displays the attitude responses and learning styles of Arab students. The person mean logit at 0.1 is slightly above and very close to the item mean logit at 0.0. This indicates that Arab students display a high positive attitude toward learning statistics but at varying probability levels. In terms of their learning styles, a majority of the students (84%) prefer to learn statistics by feeling and doing the problems. In other words, the probability of the students preferring to solve statistical problems by doing and understanding is between 0.46 and 0.76, respectively. On the other hand, only about 12% of the students prefer to watch and think about how other people (lecturer and fellow students) solve the problem, with a probability of between 0.24 and 0.55, respectively. Clearly, a majority of Arab students prefer to learn statistics by doing and solving problems.

Figure 7 shows the probability that the Arab students perceive themselves as confident (C13r), do not experience anxiety (C9R), and know the direction of the subject (C14r) is at least 0.85. A probability of at least 0.72 is observed for students who do not experience stress in learning statistics (C12r), do not find difficulties in learning statistics (C16r), and do not make lots of errors in statistical calculations (C15r). The probability that statistics is useful for solving

		Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1.	Learning statistics is exciting.					
2	I like to learn statistic topics.					
3	I never get tired of learning statistics.					
4	I do not feel bored when learning statistics.					
5	Statistics is useful in solving real life problems.					
6	Statistics is useful in my life.					
7	Statistics is relevant to my profession.					
8	Statistics is useful for making important decisions.					
9r	I have anxiety while learning statistics.					
10	Learning statistics is easy for me.					
11	I enjoy learning statistics.					
12r	I am under stress while learning statistics.					
13r	I am not confident while learning statistics.					
14r	I have no idea of what's going on in the statistics topic.					
15r	I tend to make lots of errors in statistics calculation.					
16r	I find it is difficult to understand statistics concepts.					
17	Statistics involves massive computation.					

Figure 2: Perceived attitude toward learning statistic items.

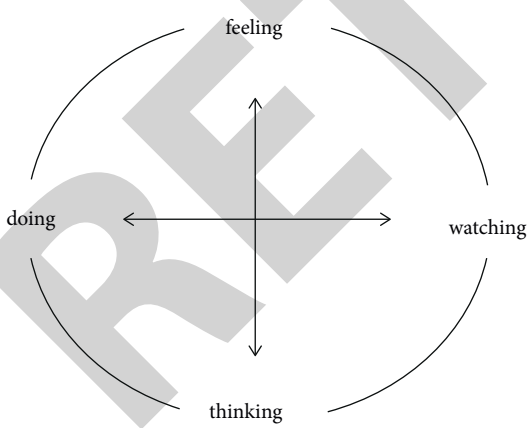


Figure 3: Instrument to gauge students' learning styles in statistics.

real-life problems (C5), useful in their lives (C6), relevant to their profession (C7), and enjoyable (C11) is at least 0.65, while the probability that the students perceive learning statistics as exciting (C1) and useful for making important decisions (C8) is at least 0.65.

A summary of the 20 things that were measured is shown in Table 2.

Table 1: Characteristics of students' learning styles based on Kolb's learning model.

		Do you prefer to think or feel?	
		Think	Feel
Do you prefer to watch or do?	Watch	45 (30%)	20 (13%)
	Do	70 (47%)	15 (10%)

Table 2 shows item reliability of 0.85, which indicates that the items are replicable for measuring the same attitude traits over a suitable range of Arab students' abilities. The mean infit and outfit for item mean square are both 1.00 logit, with z-scores of 0.2 and 0.1, respectively. The item mean logit is set to 0, and the item separation index is 2.41. This implies that things are divided into two difficulty levels.

It is shown in Figure 8 that the polytomous Rasch model is used to create a Wright map, where the person and item measurements are spread along the logit ruler. When a higher person logit is calibrated against a lower item logit, the probability that the person has a positive attitude toward learning statistics is at least 0.5. The probability is less than 0.5 if a lower person logit is calibrated against a higher item logit. The map shows that the person mean logit at 0.3 is

Program	Gender	C1	C2	C3	C4	C5	C6	C7	C8	C9r	C10	C11	C12r	C13r	C14r	C15r	C16r	C17	Watch	Do	Think	Feel
S	M	5	4	4	4	3	4	5	4	5	3	5	4	5	4	5	4	3	1	0	0	1
IS	M	3	3	4	3	4	4	4	4	5	3	3	5	5	4	3	5	2	1	0	0	1
EG	M	3	4	5	3	4	5	3	5	5	2	4	5	5	5	5	4	1	0	1	0	1
EG	M	4	5	4	2	4	4	4	4	5	3	5	4	5	4	4	5	2	1	0	1	0
B	M	5	4	4	3	4	5	5	5	4	2	4	3	4	4	3	4	1	0	1	1	0
M	M	4	5	3	4	4	5	3	5	4	4	5	4	4	3	4	3	1	0	1	1	0
M	M	5	4	4	4	4	4	5	4	4	3	5	5	4	4	4	5	1	0	1	0	1
P	M	5	5	3	4	4	4	4	4	3	2	4	4	3	5	3	4	1	1	0	0	1
EG	M	4	5	4	5	5	3	5	3	4	3	4	5	4	4	3	3	2	1	0	0	1
H	M	4	4	3	4	5	3	5	3	4	4	3	4	4	5	5	4	1	0	1	1	0
P	M	3	4	4	5	5	5	4	5	4	4	3	4	4	3	5	4	1	0	1	1	0
B	M	3	3	4	5	5	3	4	3	5	4	5	3	5	4	5	5	1	1	0	1	0
A	M	5	3	3	4	4	3	4	3	3	5	3	5	3	4	5	4	1	1	0	1	0
IS	M	3	5	4	4	5	4	3	4	5	4	3	4	5	4	4	5	2	0	1	1	0
P	M	3	3	4	3	3	4	3	4	4	3	4	3	4	5	4	4	2	1	0	0	1
B	M	4	3	4	3	3	4	4	4	3	3	4	4	3	4	3	5	3	0	1	1	0
H	M	4	4	4	5	3	4	4	4	4	3	4	3	4	5	3	4	2	0	1	1	0
EG	M	4	4	4	3	3	4	4	4	5	4	4	4	5	4	4	5	1	0	1	1	0
M	M	4	4	2	3	5	4	3	4	4	5	4	4	4	4	4	4	2	1	0	1	0
M	M	4	4	3	4	4	4	4	4	5	4	4	4	5	5	4	4	3	1	0	1	0
EG	M	4	4	3	4		4	4	4	4	3	4	4	4	4	4	5	3	0	1	1	0
MD	M	4	4	3	4	5	5	4	5	5	4	4	3	5	5	4	5	3	0	1	0	1
A	M	4	4	3	4	4	4	5	4	4	4	5	4	4	4	3	5	2	0	1	0	1
MD	M	5	4	3	4	5	3	4	2	5	3	4	4	5	3	4	5	2	0	1	0	1

Figure 4: Excel data structure as in formatted text.

```
File   Edit   Format   View   Help
&INST
  TITLE = "Learning Styles and Attitude Toward Statistics"
 PERSON = Person ; persons are ...
   ITEM = Item ; items are ...
  ITEM1 = 11 ; column of response to first item in data record
     NI = 21 ; number of items
  NAME1 = 1 ; column of first character of person identifying label
NAMELEN = 10 ; length of person label
  XWIDE = 1 ; number of columns per item response
  CODES = "012345 " ; valid codes in data file
 UIMEAN = 0 ; item mean for local origin
 USCALE = 1 ; user scaling for logits
 UDECIM = 2 ; reported decimal places for user scaling
ISGROUPS=*
1-17 L ; Attitude Likert items
18-21 D ; Competency Dichotomy items
*
linelength=123;
&END
```

Figure 5: Winsteps 3.90.2 __.prn file for a data structure.

slightly above the item mean logit at 0.0. This indicates that Malay students have a moderately positive attitude toward learning statistics.

A majority of the Malay students (89%) perceive that statistics is useful in solving real-life problems (C5) and that it is useful for making important decisions (C8). About 75% perceive that statistics is useful in their lives (C6), but at the same time they have anxiety while learning statistics; 71% are not under stress while learning statistics (C12r), and they do not find it difficult to understand statistical concepts (C16r). On the contrary, at least 75% often feel tired and not excited when learning statistics.

In terms of learning styles in statistics, a majority of the Malay students prefer to feel the experience of doing the statistical problems (Feel and Do), which categorizes them under the "Accommodating" type of learners, compared to thinking and watching what other people do (Think and Watch), which would have categorized them under the "Assimilating" type of learners.

A perusal of the Wright map in Figure 6 shows that the Malay students' attitude toward learning statistics is moderately distributed across the map between −0.5 and +1.5 logit. The distribution of attitude responses shows that the students are fairly spread out in terms of their attitude, depending on the items that they responded to. A majority of the students feel that learning statistics is tiring, less exciting, and sometimes boring. In spite of these feelings, a majority acknowledge that learning statistics is useful in solving real-life problems and that it is useful for making important decisions.

Table 3 shows item reliability of 0.91, which indicates that the items are replicable for measuring the same attitude traits over a suitable range of the students' abilities. The mean infit for item mean square is 1.00 logit, and the mean

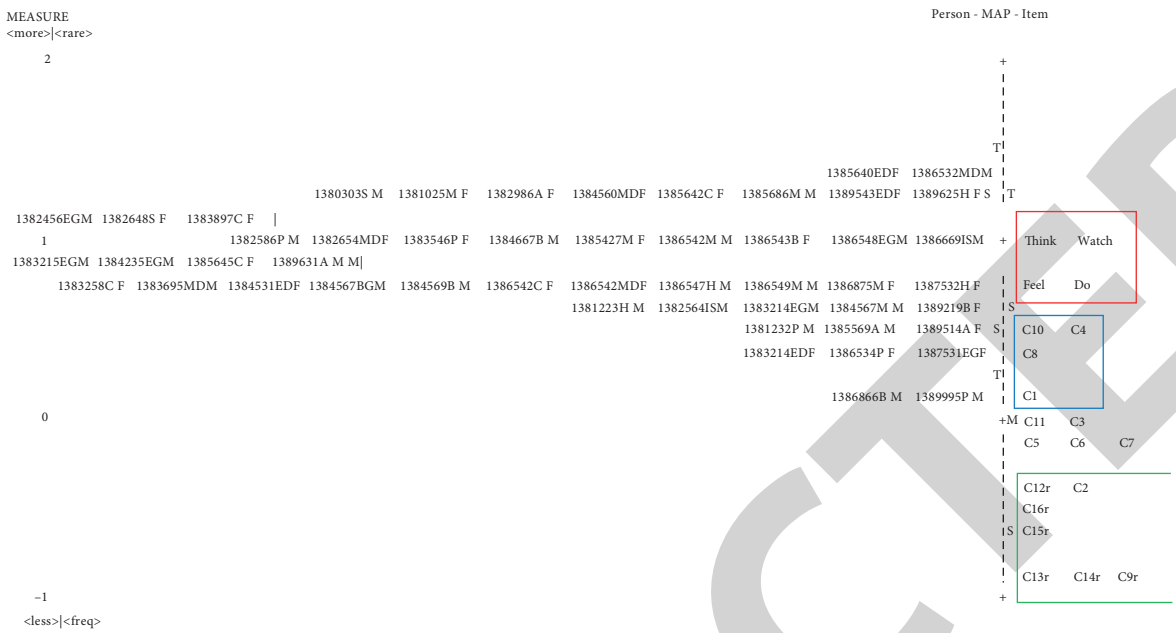
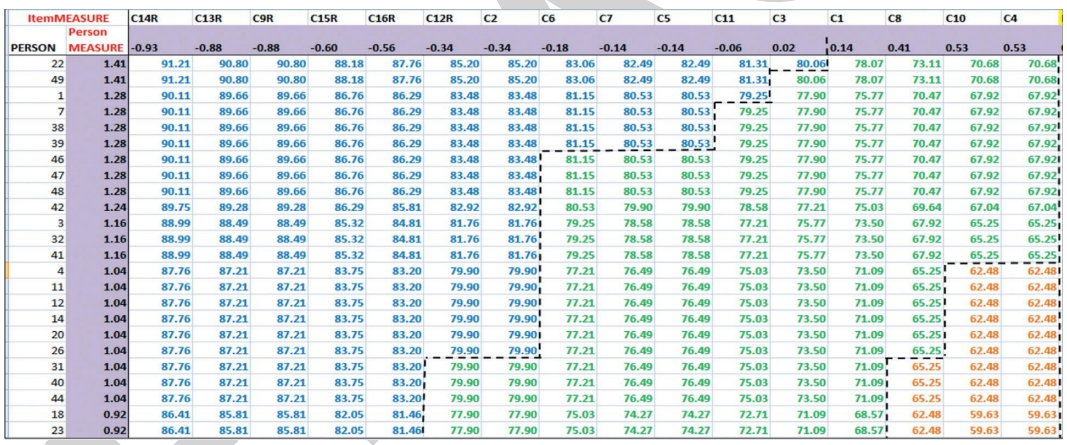


Figure 6: Wright map on the distribution of attitude toward statistics and learning styles of Arab students.



Item MEASURE		C14R	C13R	C9R	C15R	C16R	C12R	C2	C6	C7	C5	C11	C3	C1	C8	C10	C4
PERSON	Person MEASURE	-0.93	-0.88	-0.88	-0.60	-0.56	-0.34	-0.34	-0.18	-0.14	-0.14	-0.06	0.02	0.14	0.41	0.53	0.53
22	1.41	91.21	90.80	90.80	88.18	87.76	85.20	85.20	83.06	82.49	82.49	81.31	80.06	78.07	73.11	70.68	70.68
49	1.41	91.21	90.80	90.80	88.18	87.76	85.20	85.20	83.06	82.49	82.49	81.31	80.06	78.07	73.11	70.68	70.68
1	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
7	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
38	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
39	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
46	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
47	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
48	1.28	90.11	89.66	89.66	86.76	86.29	83.48	83.48	81.15	80.53	80.53	79.25	77.90	75.77	70.47	67.92	67.92
42	1.24	89.75	89.28	89.28	86.29	85.81	82.92	82.92	80.53	79.90	79.90	78.58	77.21	75.03	69.64	67.04	67.04
3	1.16	88.99	88.49	88.49	85.32	84.81	81.76	81.76	79.25	78.58	78.58	77.21	75.77	73.50	67.92	65.25	65.25
32	1.16	88.99	88.49	88.49	85.32	84.81	81.76	81.76	79.25	78.58	78.58	77.21	75.77	73.50	67.92	65.25	65.25
41	1.16	88.99	88.49	88.49	85.32	84.81	81.76	81.76	79.25	78.58	78.58	77.21	75.77	73.50	67.92	65.25	65.25
4	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
11	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
12	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
14	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
20	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
26	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
31	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
40	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
44	1.04	87.76	87.21	87.21	83.75	83.20	79.90	79.90	77.21	76.49	76.49	75.03	73.50	71.09	65.25	62.48	62.48
18	0.92	86.41	85.81	85.81	82.05	81.46	77.90	77.90	75.03	74.27	74.27	72.71	71.09	68.57	62.48	59.63	59.63
23	0.92	86.41	85.81	85.81	82.05	81.46	77.90	77.90	75.03	74.27	74.27	72.71	71.09	68.57	62.48	59.63	59.63

Figure 7: Attitude probability scores for Arab students' sample.

Table 2: Summary statistics of Arab pupils' assessed attitude items.

	Total score	Count	Measure	Model SE	Infit MNSQ	InfitZSTD	OutfitMNSQ	Infit ZSTD
Mean	166.0	49.9	0.00	0.22	1.00	0.2	1.00	0.1
SD	71.2	0.3	0.60	0.03	0.13	0.9	0.13	0.9
Max.	218.0	50.0	1.03	0.29	1.28	1.8	1.27	1.8
Min.	23.0	49.0	−0.93	0.20	0.77	−1.4	0.76	−1.4
Real MSE		0.23	True SD	0.55	Separation	2.41	Reliability	0.85
Model RMSE		0.22	True SD	0.55	Separation	2.47	Reliability	0.86

outfit is 1.01 logit, with both infit and outfit z-scores at −0.1. The item mean logit is set at 0, and the separation index for item is 3.25. This indicates that the items are separated into three levels of the item's difficulty.

7.2. Objective 3. To compare certain attitude of the students based on item characteristic curves, the following results are described. A summary of 20 measured items is shown in Table 3.

Technically, the item characteristic curve (ICC) is used to describe the distribution of the response pattern of the students toward the items based on the logit and item scores. In Figure 9, the expected and empirical item characteristic curves are constructed to observe the attitude of Arab students between different attitude items. A

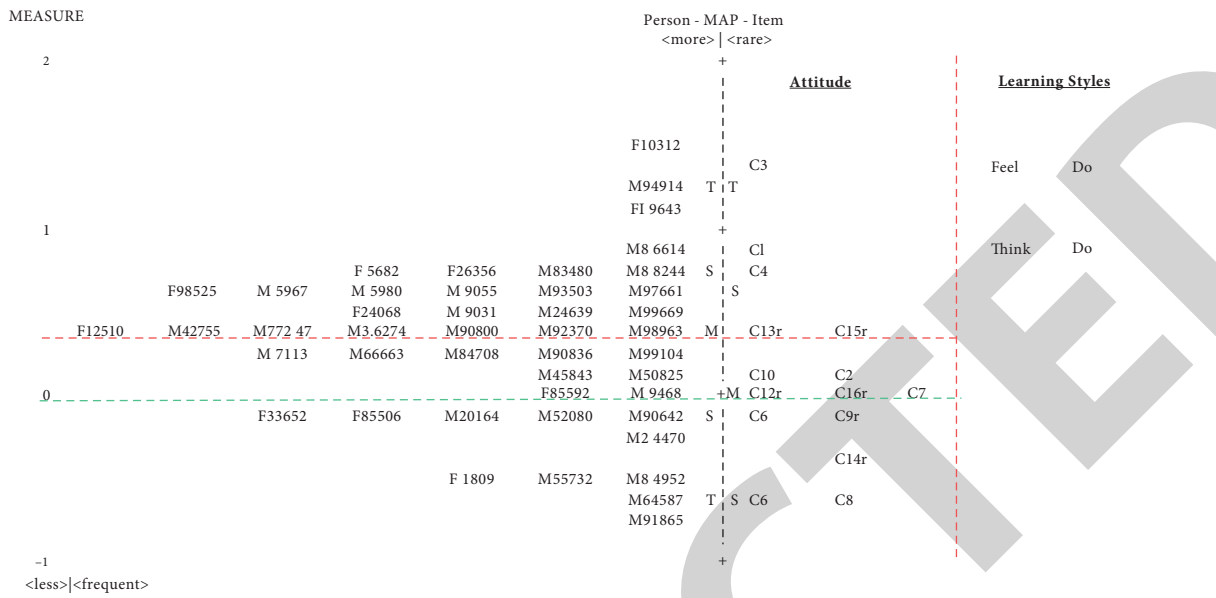


Figure 8: Wright map on the distribution of attitude toward statistics and learning styles of Malay students.

Table 3: Summary statistics of measured attitude items of Malay students.

	Total score	Count	Measure	Model SE	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Infit ZSTD
Mean	149.6	45.0	0.00	0.17	1.00	−0.1	1.01	−0.1
SD	22.2	0.0	0.61	0.01	0.31	1.4	0.32	1.5
Max.	184.0	45.0	1.40	0.20	2.04	3.7	2.00	3.6
Min.	96.0	45.0	−1.04	0.16	0.58	−2.2	0.52	−2.6
Real MSE		0.18	True SD	0.59	Separation	3.25	Reliability	0.91
Model RMSE		0.17	True SD	0.59	Separation	3.48	Reliability	0.92

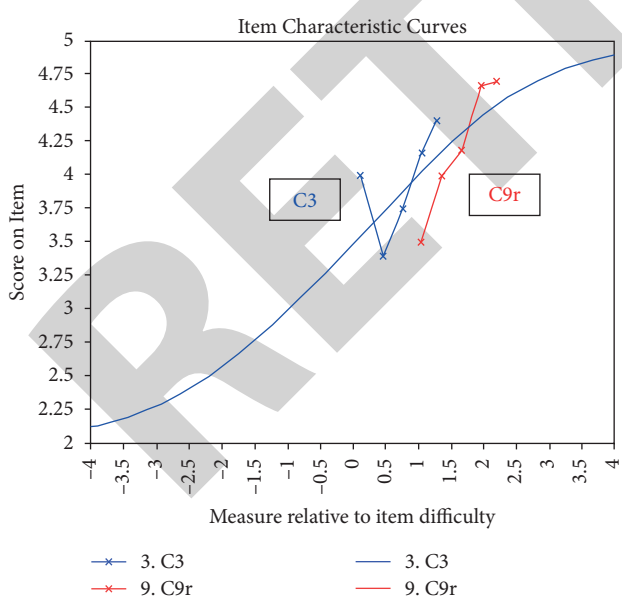


Figure 9: Attitude logit scores for Arab sample.

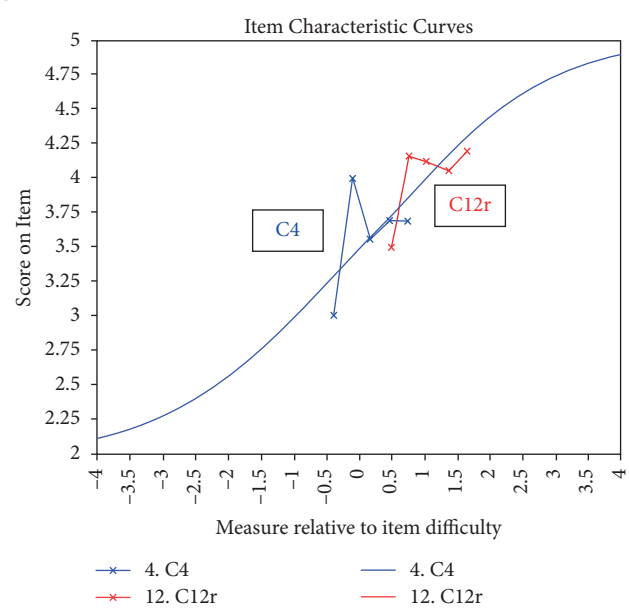


Figure 10: Wright map on the distribution of attitude toward statistics and learning styles of Malay students.

cursory look at the ICC shows that item C9r ("I do not have anxiety while learning statistics") is easier to endorse compared to item C3 ("I never get tired of learning statistics") because the response distribution for item C9r is located above the response distribution for item C3. A comparison of items C3 and C9r shows that there are more students who get tired of learning statistics

compared to those who experience anxiety while learning statistics.

In Figure 10, a comparison of two items shows that item C12r ("I am under stress while learning statistics") is easier to endorse compared to item C4 ("I do not feel bored when learning statistics") because the response distribution for item C12r is located above the response distribution for item C4. This indicates that students are under stress while learning statistics; however, they do not feel bored learning about statistics.

8. Conclusions

Research studies on students' attitudes toward statistics and their learning styles in statistics have been investigated from various perspectives. This study used a psychometric approach based on the Rasch models to explore both Malay and Arab students' attitudes toward statistics and their learning styles. The connections between the students' attitudes and their learning styles and the fact that they are from different cultural backgrounds have shown some similarities and differences in the students' attitude toward statistics and their learning patterns in statistics. A comparison of the item reliability index shows that Malay students have a slightly higher item reliability index compared to Arab students, which indicates that the attitude items are more agreeable to the Malay students compared to the Arab students, given their range of abilities. Generally, students from both the Arab and Malay cultures are classified as the "Accommodating" type with a preference for doing (active experimentation) and feeling from the experience of doing/solving statistical exercises. However, Arab students are also classified as the "Assimilating" type with a preference for thinking, reflecting, and learning from observation, while Malay students are classified as the "Converging" type with a preference for thinking (abstract conceptualization) and doing statistical exercises (active experimentation).

Data Availability

Numerical dataset used to conduct the study reported in the publication is available from corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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References

[1] Z. A. Ali and H. Rafiq, "Impact of students' preferred learning style on their attitude towards statistics," *International Journal of Information Retrieval Research*, vol. 4, no. 2, pp. 3706–3709, 2017.

[2] H. R. Ghulami, M. R. A. Hamid, and R. Zakaria, "Students' attitudes towards learning statistics," in *Proceedings of the international conference on mathematics, engineering and industrial applications 2014 (icomeia 2014)*, vol. 1660, Penang, Malaysia, July 2015.

[3] R. M. Mutambayi, A. S. Odeyemi, J. O. Ndege, Q. T. Mjoli, and Y. Qin, "A statistical analysis of students' attitudes towards statistics: a case study of undergraduate bachelor of science students at the university of fort hare," *International Journal of Educational Sciences*, vol. 14, no. 3, pp. 294–303, 2016.

[4] J. Garfield, B. Hogg, C. Schau, and D. Whittinghill, "First courses in statistical science: the status of educational reform efforts," *Journal of Statistics Education*, vol. 10, no. 2, 2002.

[5] M. K. Rosli, S. M. Maat, and R. Rosli, "Students' attitude and anxiety towards statistics: a descriptive analysis," *Research on Education and Psychology (REP)*, vol. 1, no. 1, pp. 47–56, 2017.

[6] O. Lipka and I. Hess, "Attitudes toward statistics studies among students with learning disabilities," *Numeracy*, vol. 9, no. 2, 2016.

[7] J. D. Vermunt, "Metacognitive, cognitive and affective aspects of learning styles and strategies: a phenomenographic analysis," *Higher Education*, vol. 31, no. 1, pp. 25–50, 1996.

[8] F. Marton, "Phenomenography—research approach to investigating different understandings of reality," *Journal of Thought*, vol. 21, pp. 28–49, 1986.

[9] E. Sadler-Smith, "Approaches to studying: age, gender and academic performance," *Educational Studies*, vol. 22, no. 3, pp. 367–379, 1996.

[10] S. Cassidy*, "Learning Styles: an overview of theories, models, and measures," *Educational Psychology*, vol. 24, no. 4, pp. 419–444, 2004.

[11] N. J. Entwistle and P. Ramsden, *Understanding Student Learning*, Croom-Helm, London, UK, 1983.

[12] N. Purdie and J. Hattie, "Cultural differences in the use of strategies for self-regulated learning," *American Educational Research Journal*, vol. 33, no. 4, pp. 845–871, 1996, https://doi.org/10.3102/00028312033004845.

[13] P. R. Pintrich and B. Schrauben, "Students' motivational beliefs and their cognitive engagement in classroom academic tasks," in *Student Perceptions in the Classroom*, D. H. Schunk and J. L. Meece, Eds., pp. 149–183, Lawrence Erlbaum Associates, Hillsdale, NJ, USA, 1992.

[14] K. E. Ablard and R. E. Lipschultz, "Self-regulated learning in high-achieving students: relations to advanced reasoning, achievement goals, and gender," *Journal of Educational Psychology*, vol. 90, no. 1, pp. 94–101, 1998.

[15] S. Joy and D. A. Kolb, "Are there cultural differences in learning style?" *International Journal of Intercultural Relations*, vol. 33, no. 1, pp. 69–85, 2009.

[16] B. J. Zimmerman, "Self-regulated learning and academic achievement," *Educational Psychology*, vol. 25, no. 1, pp. 419–444, 1990.

[17] P. R. Pintrich and T. Garcia, "Student goal orientation and self-regulation in the college classroom," in *Advances in Motivation and Achievement: Goals and Self-Regulatory Processes*, M. Maehr and P. R. Pintrich, Eds., vol. 7, pp. 371–402, JAI Press, Greenwich, CT, USA, 1991.

[18] D. H. Schunk, "Goal setting and self-efficacy during self-regulated learning," *Educational Psychologist*, vol. 25, no. 1, pp. 71–86, 1990.

[19] D. A. Kolb, *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, Englewood Cliffs, NJ, USA, 1984.

[20] F. M. Nasser, "Structural model of the effects of cognitive and affective factors on the achievement of Arabic-speaking pre-service teachers in introductory statistics," *Journal of Statistics Education*, vol. 12, no. 1, 2004.

[21] A. Estrada, C. Batanero, and S. Lancaster, "Teachers' attitudes towards statistics," in *Teaching Statistics in School Mathematics—Challenges for Teaching and Teacher Education. A Joint ICMI/IASE Study*, C. Batanero, G. Burrill, and C. Reading, Eds., pp. 163-164, The 18th ICMI study, 2008.

[22] A. Estrada, "Análisis de las actitudes y conocimientos estadísticos elementales en la formación del profesorado [Analysis of attitudes and elementary statistical knowledge in educating the teachers]," Doctoral thesis, Universidad Autónoma de Barcelona, Bellaterra, Spain, 2002.

[23] D. M. Roberts and E. W. Bilderback, "Reliability and validity of a statistics attitude survey," *Educational and Psychological Measurement*, vol. 40, no. 1, pp. 235–238, 1980.

[24] S. L. Wise, "The development and validation of a scale measuring attitudes toward statistics," *Educational and Psychological Measurement*, vol. 45, no. 2, pp. 401–405, 1985.

[25] E. Auzmendi, *Las actitudes hacia la matemática estadística en las enseñanzas medias y universitarias: características y medición [Attitudes towards statistical mathematics in secondary and university education: characteristics and measurements*, Mensajero, Bilbao, Spain, 1992.

[26] J. Garfield, "How students learn statistics," *International Statistical Review/Revue Internationale de Statistique*, vol. 63, no. 1, pp. 25–34, 1995.

[27] J. Garfield and B. Chance, "Assessment in statistics education: issues and challenges," *Mathematical Thinking and Learning*, vol. 2, no. 1–2, pp. 99–125, 2000.

[28] D. Tempelaar, "A structural equation model analyzing the relationship students' statistical reasoning abilities, their attitudes toward statistics and learning approaches," in *Proceedings of the 7th International Conference on the Teaching of Statistics*, ICOTS-7, Salvador, Bahia, Brazil, July 2006.

[29] J. B. Garfield and D. Ben-Zvi, *Developing Students Statistical Reasoning: Connecting Research and Teaching Practice*, Springer Science+Business Media B.V, Berlin, Germany, 2004.

[30] R. delmas, J. Garfield, and B. Chance, "A model of classroom research in action: developing simulation activities to improve students' statistical reasoning," *Journal of Statistics Education*, vol. 7, no. 3, 1999.

[31] L. A. Saldanha and F. W. Thompson, "Students' reasoning about sampling distributions and statistical inference," in *Proceedings of the Twenty-Third Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, R. Speiser and C. Maher, Eds., pp. 449–454, Educational Resources Information Center Clearinghouse, Columbus, OH, USA, 2001.

[32] D. T. Tempelaar, S. Schim van der Loeff, and W. H. Gijselaers, "A structural equation model analyzing the relationship of students' attitudes toward statistics, prior reasoning abilities, and course performance," *Statistics Education Research Journal*, vol. 6, no. 2, pp. 78–102, 2007.

[33] J. Garfield, "The challenge of developing statistical reasoning," *Journal of Statistics Education*, vol. 10, no. 3, https://doi.org/10.1080/10691898.2002.11910676, 2002.

[34] K. Allen, A. Stone, T. Reed-Rhoads, and T. J. Murphy, "The statistics concept inventory (SCI): developing a valid and reliable instrument," in *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition*, pp. 1–15, Salt Lake City, Utah, USA, June 2004.

[35] R. delMas, J. Garfield, A. Ooms, and B. Chance, "Assessing students' conceptual understanding after a first course in statistics," *Statistics Education Research Journal*, vol. 6, no. 2, pp. 28–58, 2007.

[36] N. Osman and Z. Mahmud, "Relationship between the attitude towards and competency in learning statistics among upper secondary school students at SMK Bandar Baru Sg," Buloh (Unpublished master's thesis, Universiti Teknologi MARA, Malaysia, 2009.

[37] C. Schau, J. Stevens, T. L. Dauphinee, and A. D. Vecchio, "The development and validation of the survey of antitudes toward statistics," *Educational and Psychological Measurement*, vol. 55, no. 5, pp. 868–875, 1995, https://doi.org/10.1177/0013164495055005022.

[38] A. Chapman, "Kolb learning styles," 2006, http://businessballs.com/self-awareness/kolbs-learning-styles/.

[39] J. M. Linacre, *A User's Guide to WINSTEPS*, Winsteps.com, Chicago, IL, USA, 2007.

[40] T. G. Bond and C. M. Fox, *Applying the Rasch Model: Fundamental Measurement in the Human Sciences*, Lawrence Erlbaum Associates, New Jersey, NJ, USA, 2007.

[41] R. F. Cavanagh and R. F. Waugh, "The utility of rasch measurement for learning environments research," in *Applications of Rasch Measurement in Learning Environments Research*, R. F. Cavanagh and R. F. Waugh, Eds., pp. 3–15, Sense Publishers, Rotterdam, Netherlands, 2011, https://doi.org/10.1007/978-94-6091-493-5_1.