International Journal of Management and Applied Science, ISSN: 2394-7926 Volume-4, Issue-9, Sep.-2018
http://iraj.in

TEACHING STRATEGIES TO CORRECT MISCONCEPTIONS IN DESCRIPTIVE STATISTICS

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Abstract - The purposes of this study were 1) to elicit misconception that high school students had about the concepts of descriptive statistics on 'Data Analysis' and 2) to investigate teaching strategies to correct students' misconceptions and increase statistical reasoning. Instruments were the interviewing form and synthesis of documents. As the results of the analysis from the interview and synthesis of documents, it was found that 1) high school students had serious misconceptions about 'Distribution', 'Central Tendency', and 'Dispersion' and 2) the researchers of the prior studies applied the 'innovations' and 'technologies' for teaching strategies focusing on statistical reasoning to correct misconceptions.

Keywords - Descriptive Statistics, Data Analysis, Statistical Misconception, Statistical Reasoning, Distribution, Central Tendency, Dispersion

I. INTRODUCTION

Statistics is concerned with the scientific method by which information is collected, organized, analyzed and interpreted for finding solutions from relevant information and then brings to answer the question or issues of interest. Most of the solutions are needed to use information and statistical procedures to help in decision making.

There are two main categories of statistical method. (1) Descriptive Statistics- It deals with the numerical methods to compute data such as 'distribution', 'central tendency', and 'dispersion' included graphical methods, and (2) Inferential Statistics-It deals with making inferences about the whole population on the basis of results obtained from samples.

This study was focused on collecting and analyzing high school students' misconceptions in learning descriptive statistics and selecting effective teaching strategies appropriate for correcting students' difficulties in learning descriptive statistics.
The objectives of this study were the followings:
1) To elicit misconception that high school students had about the concepts of descriptive statistics on 'Data Analysis'; and
2) To investigate teaching strategies to correct students' misconceptions and increasing students' reasoning.

II. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The researchers were interested in 'Teaching Strategies to Correct Misconceptions and Increase Students' Reasoning'. There were theories and studies impact on students' learning statistics.

EFFECTIVE TEACHING STRATEGIES

The literature review focused on effective teaching which using innovation and technology approaches for teaching statistics. These approaches are referred to student-centered approaches which place a much stronger emphasis on the learners. Each approach includes the effective techniques such as 'discussion', 'co-operative learning', and 'problem solving'.
Some advantages of each technique are suggested as follows [1]:

Techniques	Advantages
1. Discussion	It allows students to share their knowledge and experiences with teacher and friends. Also, it can help students to overcome misconceptions.
2. Co-operative Learning	It encourages students to verbalize their ideas so teacher can observe their understanding for the correct concepts.
3. Problem-Based Learning	Real life problems can help students to integrate the concepts for diversity of problem situations.

Based on the relevant research, there are suggestions for using principles of learning statistics as the following [2]:
- *Students learn by constructing knowledge.*
- *Students learn by active involvement in learning activities.*
- Students learn to do well only what they practice doing.

- Teachers should not underestimate the difficulty students have in understanding basic concepts of probability and statistics.
- Teachers often overestimate how well their students understand basic concepts.
- Learning is enhanced by having students become aware of and confronts their misconceptions.
- Calculators and computers should be used to help students visualize and explore data, not just to follow algorithms to predetermined ends.
- Students learn better if they receive consistent and helpful feedback on their performance.
- Students learn to value what they know will be assessed.

REASONING SKILLS IN STATISTICS

Reasoning skill is an important skill in problem solving. Bradstreet (as cited in [3]) suggested using real data and questions related to students' experiences for teaching because they should understand the procedure as they use them to solve real world problems instead of memorizing the formulas and algorithms. Inductive reasoning is one type of reason process in which a conclusion is drawn from particular cases. It is usually based on facts and observations and used when formulating theories and discovering relationships [4].

In the Basic Core Curriculum B.E. 2551 (A.D.2008), reasoning skill is one skill in Mathematical skills/process. The teachers integrate reasoning skill in every lesson to foster the learners think critically while they are solving the problems. In addition, the learning outcomes of mathematical skills/processes for the Grade 12 learners' performance in solving problems are given as follows [5]

This study was prepared some guidelines to design teaching strategies to correct students' misconceptions in descriptive statistics and increase reasoning skills those mentioned above by using innovation and technology.

MISCONCEPTIONS IN STATISTICS

According to the research summarized in this study showed that many teachers had problems on a variety of students' difficulties and misconceptions with respect to basic statistical concepts. Examples of students' difficulties in the prior research included:

having comparison between the utility of the mean and the median as measures of central tendency for different data set, having difficulties in using graphical presentation, having little understanding of standard deviation of different data set, etc. [6].

In this study, the researchers listed the concepts of descriptive statistics from textbooks for discussing with mathematics teachers about students' misconceptions on 'Data Analysis' as the following [7]:

Learning Objectives

At the end of this chapter the students will be able to:

1. Describe data with measures of central tendency;
2. Find arithmetic mean, median, and mode;
3. Interpret histograms and boxplots; and
4. Describe data with measures of dispersion.

Contents

1. Frequency Distribution
2. Frequency Distribution Graphically
3. Measures of Central Tendency
4. Measurement of Dispersions

According to prior research studies, students' misconceptions on above contents were found in one facet of faulty, inaccuracy, or incorrect thinking. The following examples illustrated correct conception and misconception. Secondary students considered statistics as a difficult subject because its concepts are complex [8]. Getting just a required number without understanding the methods and ideas behind made the student not clearly understand statistic concepts. Some students perceived that statistics is similar to mathematics. The difficulties they faced in comprehending statistical ideas may lead to misconceptions in statistical reasoning [9]. There are many studies about misconception of data distributions, measures of central tendency and measures of dispersion as following examples.

Example 1: Computing the Mean of Mean

Situation 1: The mean salary of 100 faculty member engineering is shown in Table 1. Find the mean for all 100 males.

Gender	Index	Engineering	Social Work
Males	N_1	90	10
	Mean salary	$90,000	$30,000
Female	N_2	10	20
	Mean salary	$80,000	35,000

Table 1 Mean Data on Salaries

***Correct conception*:** The subgroups are not the same size, the mean for the combined group must be computed as a *weighted* mean as follow:

Solution

$$\frac{N_1(\bar{X}_1) + N_2(\bar{X}_2)}{N_1 + N_2} = \frac{90(\$90{,}000) + 10(\$30{,}000)}{90 + 10} = \$84{,}000$$

Misconception: Combine the mean of different group or combine the mean of different group and divided by 2.

Solution1: Incorrect

$$\$90{,}000 + \$30{,}000 = \$120{,}000$$

Solution2: Incorrect

$$\frac{(\$90{,}000) + (\$30{,}000)}{2} = \$60{,}000$$

Example 2: The Median's Location

Situation 2: There are two different sets of data with two different medians in Figure 1. What is the difference between the sets of data if we look at the median?

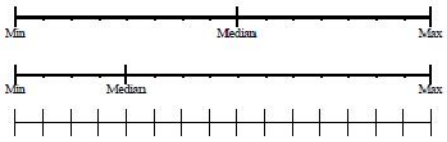

Figure 1 Median's location of different two sets

Correct conception: The median is the middle of the data is not always the middle between the minimum and maximum as shown in Figure 2.

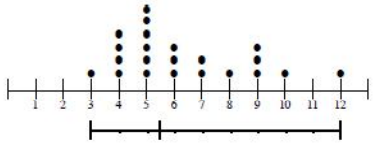

Figure 2 Median's location of raw scores

Misconception: The median is always at the middle of the minimum and maximum score.

Shiau Wei Chan and Zaleha Ismail [10] stated "students recognize that value of mean is equivalent to value of standard deviation. It means that standard deviation increases when mean increases, and standard deviation decreases when mean decreases".

In their study, Zaleha Ismail and Shiau Wei Chan [11] found the misconception in central tendency by showing the histogram data. First, the mean was found by adding up height of histogram data and dividing by the number of values on the horizontal axis. Second, Students thought that the highest point on the histogram was mode of the data set. Last, the students took the frequencies of the data value on the histogram sort by ascending, and they thought that the middle of data value was median.

INNOVATION AND TECHNOLOGY

Statistics deals with variability and uncertainty data or information. When we manage the data, using innovation and technology can make manipulation and visualization of data easier.

In recent years, the approaches used for teaching statistics have changed with an increased focus on using active learning strategies, using real world data [12], including discussion, co-operative learning, and problem solving. Moreover, using technology allows students to understand, make a conjecture, investigate, and explore the data.

Innovation in Teaching Statistics

The effective teaching strategy has shifted from formulas and computations to some deeper concepts as well as their connection to the real world [13]. The appropriate use of innovation in teaching statistics can encourage students' active learning.

An active learning environment is an important facet of the constructivist approach to teaching and learning statistics. Examples of educational innovation to support active learning method much more on the following alternatives:

Cooperative Learning

Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning [14]. Some examples of cooperative learning strategies are as the followings:

Name of Strategy	Benefit
Think-Pair-Share	It engages all students in their learning and it can be done quickly.
Jigsaw	Students engage with one another and hold them accountability for their learning. It allows students to become the teachers.

Discussion

Discussion is the teaching strategy provided with opportunities to learn by talking with their peers and by engaging students' responses inform the teacher questions. In particular, National Council of Teachers of Mathematics (NCTM) suggested some strategies for facilitating productive discussions, for examples, 'choose high-level mathematics task', 'explore incorrect solutions', 'select and sequence the ideas to be shared in the discussion', 'use teacher discourse moves to move the mathematics forward' and 'draw connections and summarize the discussion' [15]. In addition, the teacher can apply questioning technique to encourage and validate students' responses with subsequent questions.

Problem-Based Learning (PBL)

Problem-Based Learning is a teaching method in which complex real-world problems are used to develop critical thinking skills, problem-solving skills, and communication skills. The PBL can also provide students' opportunities for working in groups, making decision logically, and workout a deeper understanding of concepts and principles, and life-long learning [16].

Technology in teaching Statistics

There are the powerful tools to support students' learning and consistently challenge students to improve their statistics concepts. Furthermore, these tools have many features that are convenient to use and save time for helpful feedback. For examples, mobile applications: Mathway, Statistics Calculator, Stats Calc, and StatSuite and computer software: Excel, Fathom and ThinkerPlots.

The mobile application is very useful when the situation set up a statistics problem that students have to calculate the problem by their hand then students must be explaining each step. Students used to solve the problem, and then use mobile application to check the work.

III. RESEARCH METHODOLOGY

SAMPLE

Sample were ten lecturers from two programs:
- 6 lecturers were from mathematics program
- 4 lecturers were from statistics program

RESEARCH INSTRUMENTS

1) Interviewing form composed of students' misconceptions in descriptive statistics.
2) Synthesis of documents for synthesizing research documents

RESEARCH PROCEDURE

The procedure of this study was divided into two steps: (1) to elicit students' misconceptions by interviewing 10 lecturers from mathematics program and statistics program, and (2) to investigate teaching strategies to correct students' misconceptions and increase reasoning skills by synthesizing research documents and summarizing the responses from interview.

DATA COLLECTION

The researcher collected two types of data as follows:

Quantitative data: the frequency of responses on students' misconceptions in 3 categories of 'Data Analysis'.

Qualitative data: the types of innovation and technology applied in teaching descriptive statistics and increasing students' reasoning skills.

DATA ANALYSIS

Researchers analyzed quantitative data for Objective 1 and qualitative data for Objective 2 as the following details:

For objective 1: The researchers analyzed 10 lecturers' responses on students' misconceptions in 3 categories on distribution and graphic presentation, central tendency, and dispersion.

For objective 2: The researchers summarized prior research documents focused on teaching strategies using innovation and technology and then design guidelines for the classroom action in the next academic year as school internship.

IV. RESEARCH FINDINGS

Objective 1:

The data were analyzed by presenting the graphic frequency distribution of lecturers' responses about students' misconceptions in descriptive statistics on 'Data Analysis' as shown in Figure 3.

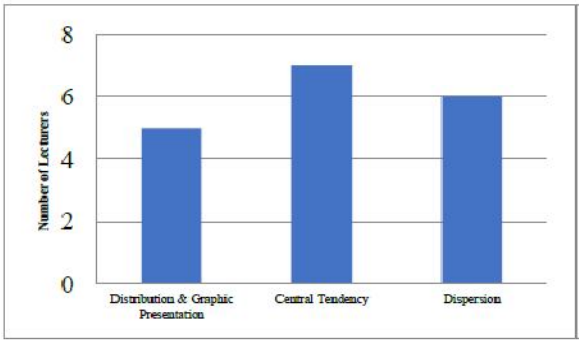

Figure 3 Lectures' responses on students' misconceptions

Objective 2

The data were divided into 2 characteristics of base of learning – 'Innovation' and 'Technology'. Each base of learning indicated teaching strategies as shown in Figure 4.

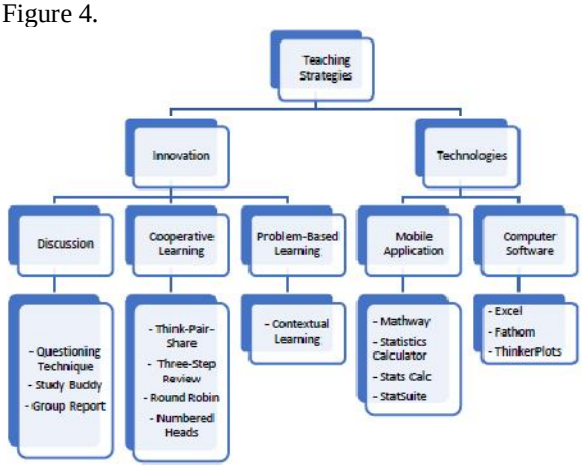

Figure 4 Guideline for Teaching Strategies using Innovation and Technology

DISCUSSION

Researchers conducted this research based on the practices from the experienced lecturers and from summarizing the prior research studies. The results showed that the most lecturers' responses to students' misconceptions was the topic on 'Measure of Central Tendency' and the least was 'Distribution and Graphic Presentation'. For the topic on 'Measure of Dispersion' was the second most opinions. However, there are some dangerous in the misconceptions of those topics. In situations where there are two or more homogeneous subgroups, the computation of mean, median, or mode can produce a result that does not adequately describe any of the subgroup data. In light of the research on teaching strategies, teachers know how to not just 'use' innovation and technology but to make it an effective part of teaching and learning process to engage students in learning effectively and overcome students' misconceptions [17, 18]. Teachers also need to make sure that all of

information is accurate and up to date before presenting them to the students and help students reconstruct and internalize their knowledge, based on critical and creative thinking.

LIMITATIONS

Although this research has reached the objectives, there were some limitations. First, because of the time limit, this research was conducted at the end of semester at SSRUIC before going to Practicum School in the next semester. Second, the ten lecturers in joining interview were not good representative of mathematics teachers from high schools. Therefore, to generalize the results for larger groups, the study should have involved more samples at different levels.

RECOMMENDATION

The research that has been done for this study has highlighted a number of topics on 'misconceptions in descriptive statistics' and teaching strategies based on 'innovation and technology'. There are also several techniques for further development usefully applied to correct students' misconception.

CONCLUSION

The problem of students' misconceptions in learning descriptive statistics can be eliminated. It will, however, take time to apply a variety of teaching strategies as well as monitoring students' performance to meet standard learning outcomes.

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