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INTEGRATING TECHNOLOGY INTO CLASSROOM INSTRUCTIONS FOR REDUCED MISCONCEPTIONS IN STATISTICS

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ABSTRACT. Misconceptions in statistics among students of non-statistics major are quite common. This paper will present the humble efforts of the author in trying to reduce misconceptions among her statistics students using technology. The examples were drawn from the teaching and learning of statistics to Master of Technical and Vocational Education students in the Universiti Tun Hussein Onn Malaysia. EXCEL spreadsheet, power point presentation slides and a concept-mapping tool were integrated into classroom instructions on descriptive statistics. Increased class-room interactions were observed through out the learning process and a decrease in the percentage of students committing the specific misconceptions were recorded.

KEYWORDS. Statistics Education, Misconceptions, Technology, Teacher Education.

INTRODUCTION

Statistics is an important tool not only in research but also in everyday usage. Statistics knowledge is not only relevant to those who intent to become statisticians but also to others such as teachers, engineers and businessperson. Therefore, some training in statistics is provided in almost all higher degree programmes including engineering, teacher training and medicine.

Understanding of statistical concepts however does not come easily to many students and as such more and more educators are embarking on research on statistics teaching and learning (Callaert, 2006; Tempelaar, 2006; Rumsey, 2002; Keeler and Steinhorst, 2001). Hard to eradicate misconceptions have been found at all levels of education including higher degrees as well as among teachers and lecturers who teach statistics and research methods (Krauss and Wassner,

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2002 in Batanero, 2004.). Statistics misconceptions have been observed among university students on various topics including associations and correlations (Morris 1998; Estapa and Sanches Cobo, 2001), hypothesis testing (Lecoutre and Lecoutre 2001 in Batanero 2004) and probability (Keeler and Steinhorst, 2001).

Institutional context of the study

Statistics is one of the subjects taught to the Masters of Technical and Vocational Education students in the Universiti Tun Hussein Onn Malaysia (UTHM). The students who wereenrolled into this programme came from diverse undergraduate background such as engineering, business studies and information technology. Statistics is taught during the second semester, with two hours of lecture and three hours of laboratory work. Teaching and learning activities include lectures, practices on using statistical package and spreadsheets, mini-projects, individual and group presentations by students.

The statistics course is at the introductory level with descriptive statistics taking seven weeks, which is 50% of the semester time. The rest of the semester is dedicated to the teaching and learning of inferential statistical techniques. Topics in the descriptive statistics include scales of measurements, data summarization and presentation, associations and correlations between variables. Most students have come across descriptive statistics before except for the topic of association and correlation between variables where students are new to it. In this topic, students are taught how to represent associations and correlation between different types of variables using tables and scatter diagrams and how to estimate associations using the Pearson correlation method and the Spearman rank methods. This article will highlight some of the difficulties students experience in learning about associations and correlations and the initiatives that have been taken to help these students.

The problem

Although statistics is not something new to most of our education students, the emphasis of their previous learning was mostly on calculations and memorization of procedures rather than on the development of statistics understanding. Therefore, most students perceive statistics as nothing more than numbers and formulae with limited use in everyday life or their future profession. Furthermore, some students believe that they understand statistics if they are able to state and insert numbers into formulae which is erroneous because statistics is not about plugging in numbers into formulae, but a process for gaining information (Chance, 1997 in Rumsey, 2002) and doing statistics is not equivalent to understanding statistics (Gal, 2000 in Rumsey, 2002). For example, student's ability to calculate standard deviation does not demonstrate a student's ability to understand what the standard deviation is and what it measures or how it is used. Furthermore, students also feel that the usefulness of statistics education is limited to getting correct answers in tests and examinations. Typical of Asian students, these students are also quite passive in class.

This article will focus on the initiatives taken by the author in trying to eradicate some of the misconceptions students have related to descriptive statistics. Examples will be drawn from the teaching and learning of the topic on associations and correlations because this topic often generates the most interesting misconceptions among students. Teachers also often overestimate students' ability to understand the various concepts under this topic. While teaching this topic to her education students the author frequently observes the following mistakes being made such as,

(i) Mistakes in interpretations of correlation coefficients that includes

- treating negative correlations as if there are no correlations
- ignoring the negative sign in negative correlations
- interpreting a high correlation as statistically significant
- interpreting a low correlation as not statistically significant

(ii) Mistakes in the computation of coefficient correlations that includes

- computing correlation coefficients for two sets of data that come from two independent sources

(iii) Making a conclusion of causal relationship when two variables are correlated

- treating one variable as the cause and the other as the effect

The misconceptions are not limited to the above but those are the most common ones. Studies on misconceptions among western students indicated that there are three main types of misconceptions specific to correlation coefficient namely, determinist conception, unidirectional conception and causal conception (Batanero, Estapa, Gordino and Green, 1996 in Estepa & Sanches Cobo, 2001). Determinist conception refers to students' belief that correlated variables should be linked by a mathematical function; unidirectional conception refers to the belief that an association only exists if the sign of the coefficient is positive and perceive a negative correlation as a sign of independence. In the causal conception, a person believe that that there is a cause and effect relationship between the variables. Morris (1997a) and Morris (1997b) found that some students believe that a negative correlation coefficient means a weaker correlation compared to a positive correlation. These misconceptions are similar to what have been found in UTHM.

Current computer technology due to its multimedia capabilities has the potential to be a useful tool in the teaching and learning of statistics. Morris (1998) who designed a computer assisted learning courseware (LINK) to address this particular issue found that technology in the form of students' self-paced learning courseware is helpful. In this article, the author would like to share some of the efforts made to eradicate these misconceptions using readily available technology and applications namely, the computer, EXCEL spreadsheet, power-point presentation slides and concept-mapping tool.

METHODOLOGY

The technology supported initiatives are active power point presentation slides, interactive excel spreadsheets and technology-supported concept mapping.

Active power-point presentation slides

Power point presentations is often said to be responsible for one way communication and passive learning but it does not have to be so. Designed effectively it can be an effective tool for creating an active learning environment which is the key to effective learning. Confronting students with their misconceptions has also been found to be effective in eliminating their misconceptions. Guided by these principles, the author created her power-point presentations slides in such a way that they promote active responses from students and active learning reflection by students on their current conceptions of correlations. Instead of giving notes to students on the meaning of correlation coefficients, short problems were posed to students to think about and to give their responses to.

Figure 1 illustrates one such problem. In this slide, students were given one correlation coefficient problem, asked to interpret the coefficient and to explain the reason for their answers. As the task appeared to be relatively simple, students were eager to participate in the activity. Many volunteered to give their interpretations and the reasons for these interpretations and active discussion were thus generated among students. As expected, some students gave the correct answers but with wrong reasons while there were others who got both of them wrong. The author withheld the correct answer at this junction and more problems were to follow (Figure 2 and

Figure 3). Students continued to eagerly give their interpretations and justifications and all the while, no correct answers were given.

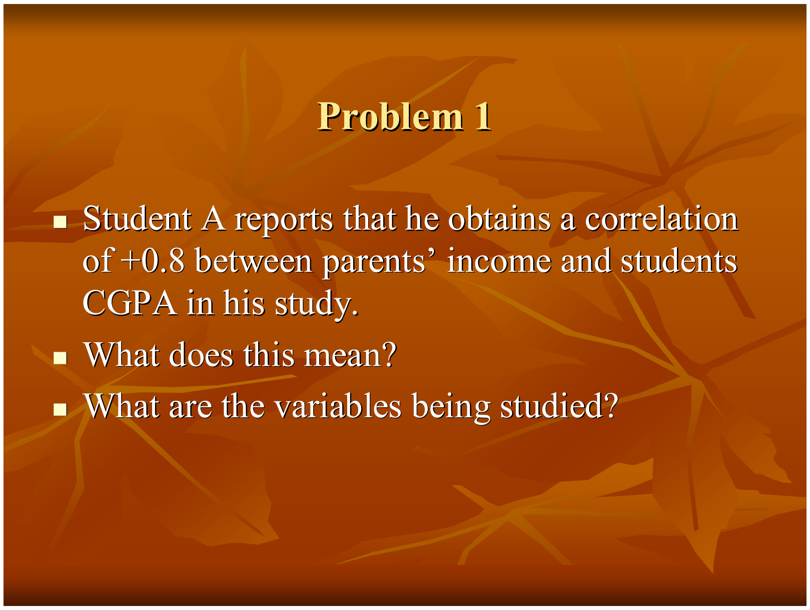

Figure 1 A problem assessing students' understanding of correlation coefficient

After a few of such activities, the author brought the students back to the first problem and started to discuss the correct answer. Those who got the right answers were naturally happy but those who got them wrong appear to be very surprised that they were wrong and insisted for explanations. At long last, the passive students have become active. Apparently, by doing these activities, students were forced to confront their long-held misconceptions and to make the appropriate alignments with their existing knowledge structures.

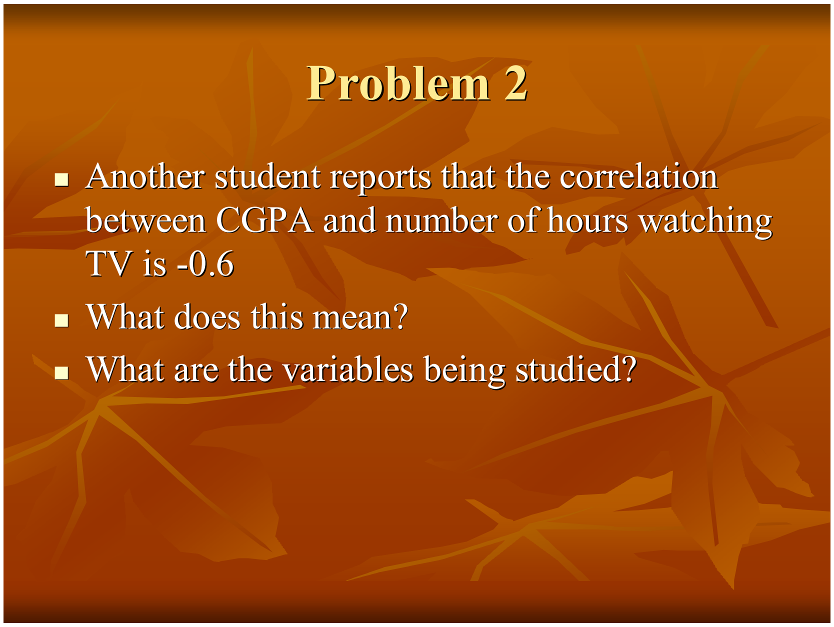

Figure 2 A problem on meaning of negative correlation coefficient

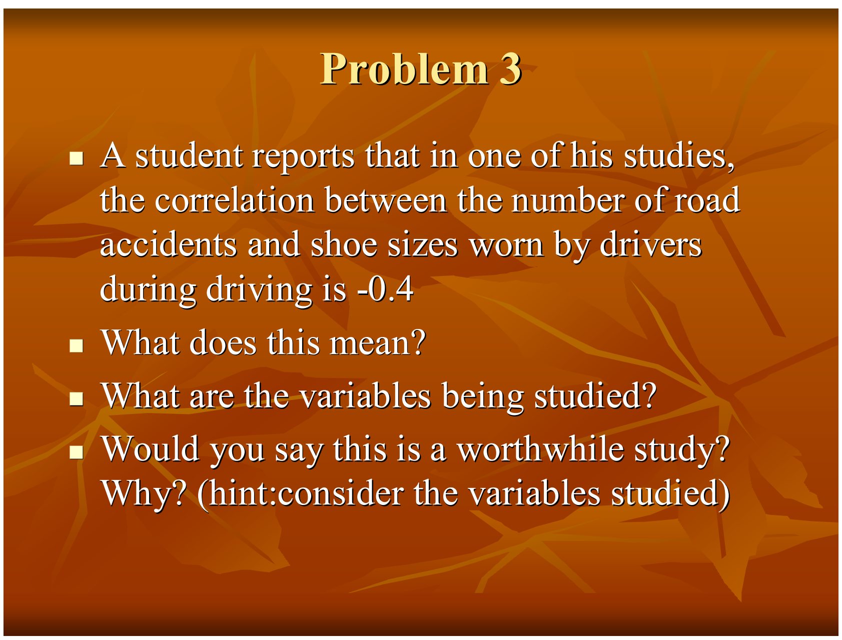

Figure 3 A problem on the meaningfulness of relationship

Interactive Excel Spreadsheets

One of the assumptions for using either the Pearson method or the Spearman rank method for estimating linear associations between variables is the linearity of relationship. However, many students did not understand what linearly related means. A scatter diagram is a good way to visually describe such a relationship. Many students also fail to understand the meaning of low correlations, positive correlations and negative correlations. This is because correlation coefficient is something that is abstract because it is a "number with a meaning". The relationship between data and their representations must be clearly illustrated to help students understand the meaning of correlation coefficient.

For learning to occur, students must be presented the materials that are meaningful to them, usually starting from the concrete concept and progressing to the more abstract materials/concept. The interactive spreadsheet activity was designed to achieve this objective. The activity consisted of three sub-activities namely, gathering data on given variables, presenting the relationship between the variables graphically and computing the correlation coefficient. In one such activity, students were asked to gather data on their friends' height and weight and to key in these data into a spreadsheet in two rows. Once this activity was completed, students were asked to construct the scatter diagram for these data with the guidance from the teacher if necessary. A short discussion on the scatter diagram would then follow. Lastly, students were asked to compute the correlations coefficient for the data using the function that is available in excel. Once, the coefficient was computed, students would then be asked to change the data according to instructions to see the changes that occur in the scatter diagram and the correlation coefficients. By doing these activities, students could see the relationship between the source of data, the data, the graphical representation of the data and the coefficient correlation that is associated with the data. The multiple representations (scatter diagram and coefficient correlation) help to reinforce the meaning of correlations coefficients. Figure 4, 5 and 6 show such spreadsheets.

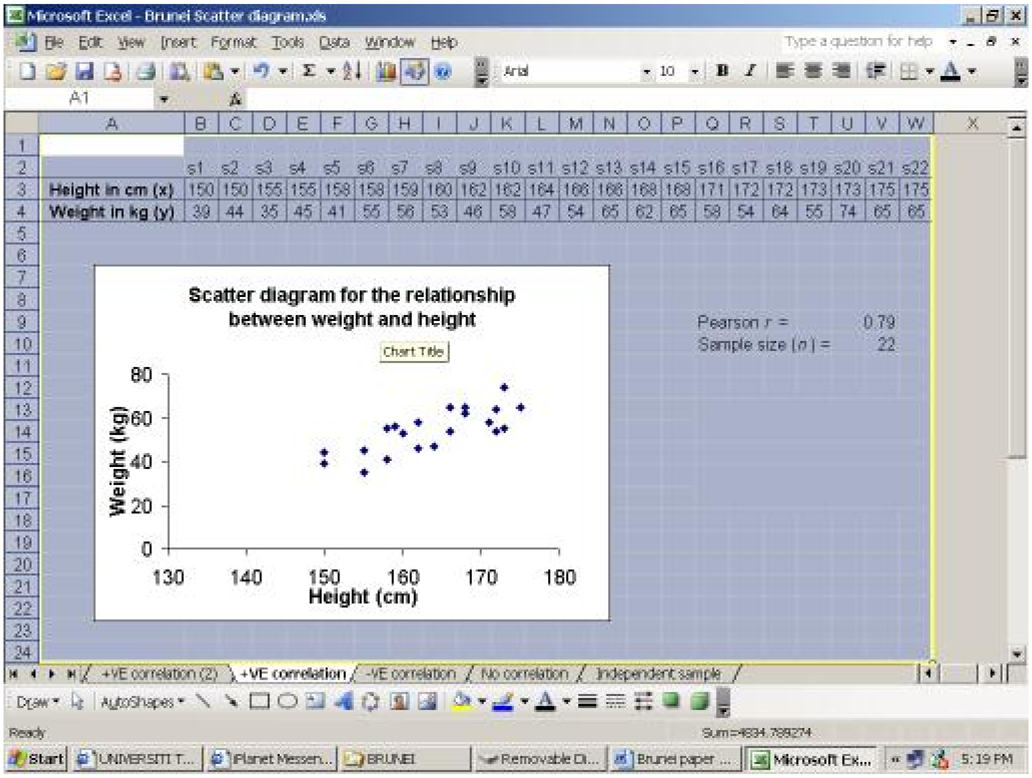

Figure 4 Relationship between data, scatter diagram and positive correlation coefficient

To help eradicate misconception (ii), students were asked to do an individual take home mini project. In this project, they were asked to gather data on students' heights from a given class A and students' weights from another given class, class B. Individually; students were asked to construct the scatter diagram and to calculate the correlation coefficient for the two sets of data that they had gathered. In class, students shared information on their work. By this time, they would discover that different coefficients could be computed from the same data sets depending on how the data were paired. The different ways on how people paired their data and the different coefficients associated with the same sets of data were enough to dispel the habit (for most students) of correlating two sets of data that come from unrelated sources.

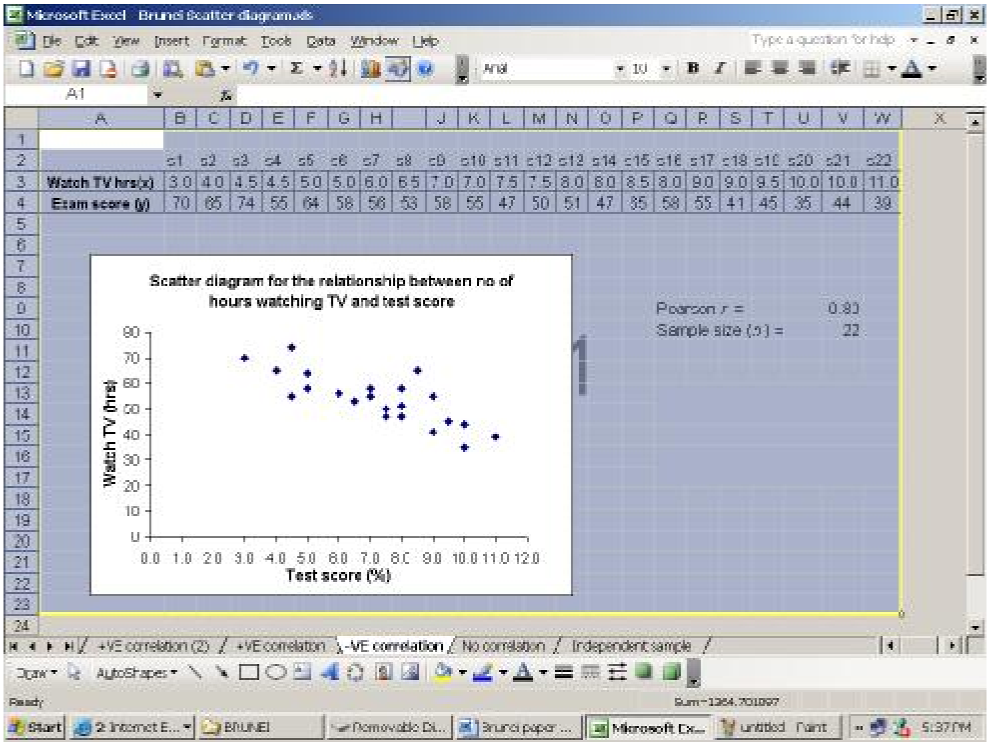

Figure 5 Relationship between data, scatter diagram and negative correlation coefficient

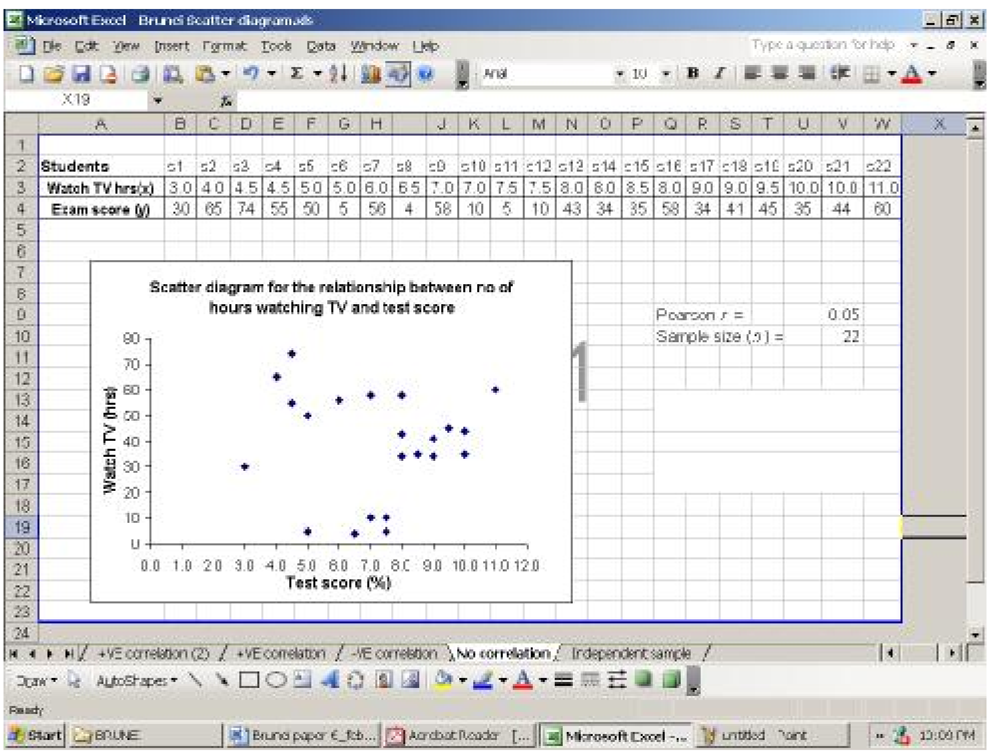

Figure 6 Relationship between data, scatter diagram and zero correlation coefficient

Technology Supported Concept Mapping

Concept maps have been found to be useful in a variety of applications, in the teaching of the different sciences and mathematics. A concept map is a graphical based method that shows the relationships between the main concept and several other sub-concepts (Novak & Gowin, 1984). Its basic principle is 'the use of simple comprehensive texts containing facts, definitions and principles'. A concept map drawn by a learner can be used as a diagnostic tool as well as a discussion tool for creating a better understanding (Brinkmann, 2005 and Kinchin and Alias, 2005). It can also be used as a self-assessment tool that promotes understanding. This is because the effort in trying to construct the concept map forces the person who draws it to confront his/her pre-conceived ideas and understanding of the concept and to further seek clarifications where necessary (Inman, Ditson & Ditson, 1998; Ellis, Al Rudnitsky & Silverstein, 2004)

However, creating a concept map is not an easy task; it is an art as well as a science, involving an iterative process that leads to a map that is often unique to one particular person. The number of iterations required is dependent not only on a person's expertise in the subject content but also on their concept mapping skills. For a novice learner, with limited subject matter knowledge as well as limited concept mapping skills, constructing a map manually could be a very discouraging experience. In this case, the use of technology-supported concept mapping can motivate students to persist in producing a good concept map that reflects their understanding and knowledge of the subject matter in question. Thus, the map will be a better indicator of their existing subject matter understanding, which can be used as a diagnostic tool as well as a discussion tool among students and lecturers.

At the author's institution, the concept-mapping tool developed by the Institute for Human and Machine Cognition (IHMC), IHMS CMap tool was used for concept mapping activities. During such activities, students were asked to draw concept maps on a given topic or concept and these concept maps were later discussed in class. An example of a concept map produced by students on associations is illustrated in Figure 7. This concept map has cross-links indicating a higher level of understanding of the students. A typical concept map by a student with a lesser understanding would be a either a spoke type or a chain type.

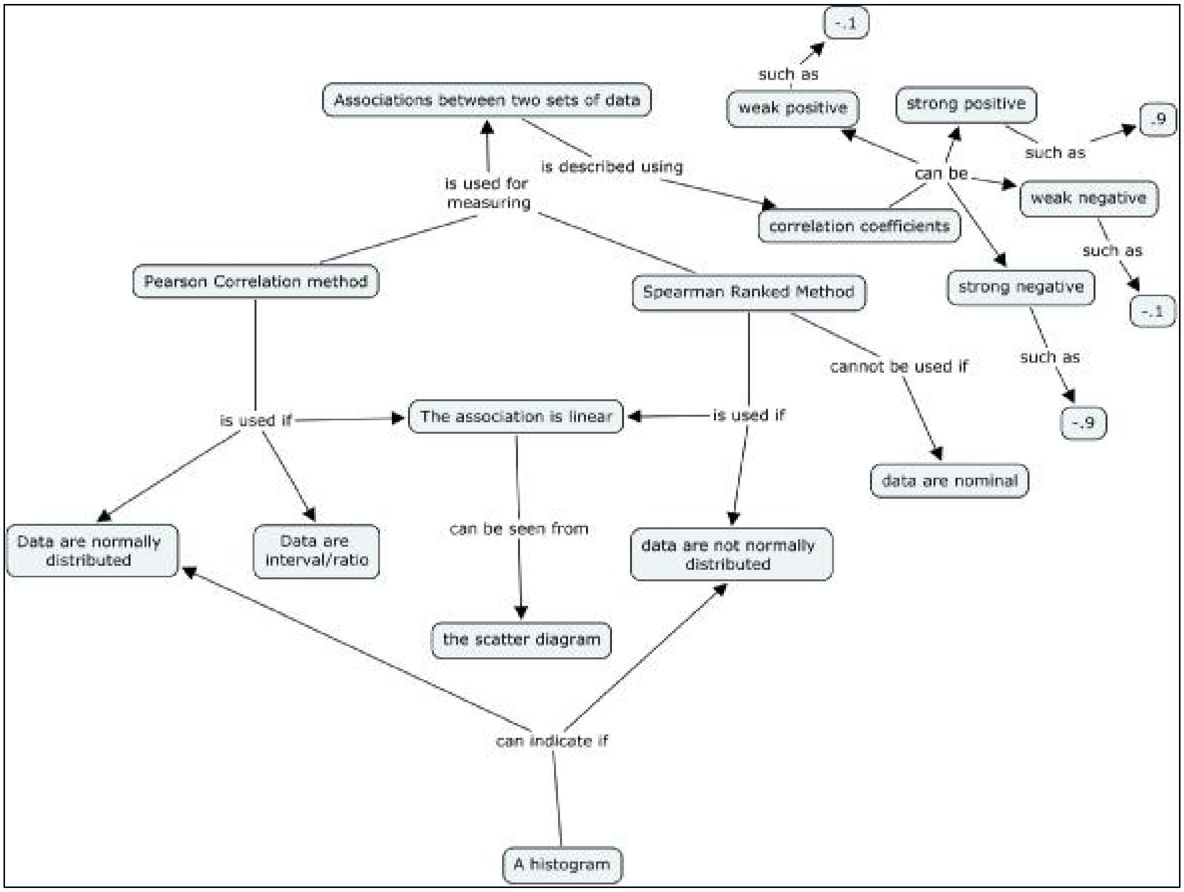

Figure 7 An example of a concept map for association between variables

OUTCOMES OF LEARNING INITIATIVES

Outcomes of the technology supported learning initiatives on students were inferred from students' reactions toward the use of technology and the long-term transfer of learning.

Students' reactions towards the use of technology

Data on students' reactions towards the initiatives were gathered using an eight-item questionnaire. Students (n=38) were asked to give their level of agreements to given statements on a rating of 1 to 4. A rating of 1 indicates that the student strongly disagrees with the statement and a rating of 4 indicates that he or she strongly agrees with it.

The mean rating obtained on the questionnaire was 3.26 (out of a maximum of 4), with a standard deviation, s = 0.29. A one-sample t-test was used to test whether this mean value is statistically significantly different from that of a chosen criterion. The chosen criterion in this case was 2.5, which is the mid-point between 1 and 4. The results of the analysis showed that there is a statistically significant difference between the mean rating on the questionnaire and that of the criterion, p=.00 and t =16.14, df = 37 with the mean rating by students higher than the criterion.

Students' positive reactions to the intervention were further supported by their responses in their weekly journals. One such journal indicated a student positive reaction towards the concept mapping activities; "*Dengan membuat peta konsep saya merasakan agak mudah memahami tajuk ini walaupun ringkas tapi ianya padat dan mudah. Cara ini adalah yang paling terbaik bagi saya.*" ("By constructing concept maps, I feel that the topic is easier to understand, even though it [the concept map] is short, it is simple and concise. This method is the best for me").

Long term learning transfer

Magnitude of learning transfer was inferred from students' statistics performance in their final semester examination. The final semester examination paper consisted of 25 closed ended (multiple-choice) items and five structured items that contributed to 75% of the total score. The emphasis of these items is on assessing students' understandings rather than their ability to memorize information. As such, for the open-ended items, students were not only required to show how a problem was solved but they were also asked to explain why a specific solution method was chosen instead of the alternatives.

Previous examination results from 2002 to 2006 on the descriptive items ranged from 16% to 65%. On the other hand, the mean score for the descriptive statistics items in the semester where the intervention occurred was 80%. The overall performance on statistics was also much better with scores ranging from 41% to 89% in contrast to their performance in the previous semesters that ranged from 20% to 85%.

LESSON LEARNT BY THE AUTHOR

Seeing students becoming more engaged is highly rewarding indeed but all the activities are not devoid of challenges. For the first initiative, the use of power point presentation slides does help in the authoring of the materials. However, much careful and creative thoughts are needed to design suitable materials for the power point presentation slides to elicit the desired responses. Some of the questions that guide the design include "what type of questions should be asked?" and "what kind of problems should be posed that will promote the desired thinking process" and "what are the desired thinking process?" In other words, the active power point slides require more thoughts and efforts from the teacher to make them more effective because as suggested by Rossman and Chance (2004), students' misconceptions need to be anticipated before they can be addressed.

The interactive EXCEL spreadsheet requires the least amount of outside class preparations for the teacher. However, it does require a lot of class-time because data gathering and entry were carried out in class. The teacher needs to be patient and not try to use a short cut by providing data in a disc for example. The author observed that the sequential act of data gathering, data entry and data analysis did appear to help foster the link between reality (data) and their representations- resulting in better understanding.

The concept mapping exercise on the other hand does not require many efforts from the teacher but appears to be most challenging to students. They kept asking whether their concept maps were correct. Students were not used to open ended problems where there is no one correct answer. Furthermore, the finished concept maps by different students are rarely identical, creating high anxiety among some students who were looking for that "one correct answer". However, this anxiety was not totally a bad thing; to come up with "the correct answer" some students became more motivated to work collaboratively with their friends. Thus, in constructing the concept maps, students benefited in several ways. At the initial stage of concept mapping, they were forced to think about the concept that they were constructing and in the process, their lack of understandings of the concept were revealed to them providing the opportunity for self-evaluation. The final concept maps were also useful for students-teacher discussions as well as for a class-discussion, which leads to a better understanding of concepts for all. In summary, the concept mapping activities did not simply provide an opportunity for discussion; they also provide opportunities for assessment and evaluation of students' learning. What a teacher needs to do is to be open minded enough to see many possibilities in their students' work.

CONCLUSION

Technology is not the answer to every problem that we face in our endeavours to help students learn statistics. However, with proper considerations of learning needs, technology can be incorporated into our daily teaching and learning processes to enhance the learning experience of our students and hopefully this will improve their understandings of important concepts and issues related to the subject matter. In the author's own experience, students were very receptive towards the technology supported initiatives undertaken, resulting in students being more engaged and active in their pursuits of learning statistics. The transformation from being passive learners to active learners may have contributed to the better performance in the end of semester examination. As usual not all students benefited from these activities with some still strongly holding to their misconceptions.

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