The Effects of Students' Cognitive Styles upon Applying Computer Multimedia to Change Statistical Misconceptions

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Abstract: Computer multimedia is seen as a good tool to help students, by integrating the diagram and text representations, to change their statistical misconceptions. However, students' cognitive style may influence their statistical learning with computer multimedia. The purpose of current study was to adopt an experiment to explore the relationship among students' cognitive styles, learning processes and learning performance under students learning with computer multimedia for eradicating statistical misconceptions. Twenty eight undergraduates with different cognitive styles (imagers or verbalizers) were selected as the subjects. The study results displayed that students with different cognitive styles indeed show preference in different representations and then have different learning processes during learning with computer with multimedia. Besides, both imagers and verbalizers can effectively reduce their statistical misconceptions by learning with computer multimedia. However, study found that the imagers can reduce misconceptions through learning with computer multimedia more effectively than the verbalizers

Introduction

Confronting the rapid growth and expansion of information in the contemporary society, the statistical understanding and application are essential skills for various walks of life. However, some studies have shown that students may still hold several statistical misconceptions after they have taken the related courses (Morris, 2001). Therefore, it is suggested that computer multimedia can help students by integrating the diagram and text representations in statistical concepts to eliminate statistical misconceptions (e.g., Yu & Behrens 1995).

However, some researches have shown that students' own personal characteristics would influence their learning with the aid of computer multimedia. Of all students' personal characteristics, the cognitive style is often seen as a very important variable. Riding and Rayner (1998) stated that the cognitive style is seen as an individual's preferred and habitual approach to both organizing and representing information, which affects the individual's learning process and is a consistently stable dimension. Effken & Doyle (2001) also pointed out that students with different cognitive styles would show different preferences for the presentation of the computer simulation system, so as a result, cognitive styles would contribute to the differences in their learning effects.

Text or diagram presentations are often used for the computer-assisted statistics learning system to facilitate learners to learn statistical concepts. Some studies have shown that students' learning results were often affected by their preferred cognition of the text or diagram. Riding, Buckle, Thompson & Hagger (1989) found that students with different cognitive styles (verbal or visual cognitive style) may employ different learning strategies under different learning environments. For example, students intendto prefer, or choose, the representation conforming to their cognitive styles. Riding and Sadler-Smith (1997) also recognized that the cognitive style reflects the qualitative rather than the quantitative differences between individuals in their thinking processes. However, most of the earlier studies about the relationship between students' cognitive styles and computer-assisted learning systems mostly focused on the learning effects, rather than the in-depth analysis of the learning processes.

Therefore, the current study concentrated on the learning processes, compared the effects of the change for the statistical misconceptions through the aid of the computer, resulted from the different cognitive styles (verbalizer and imager), and compared the differences of learning processes created by different cognitive styles.

Research Methods

Research Subjects

In the current study, 855 university freshmen (from different departments, average age was about 19) in Taiwan completed the Style of Processing scale (SOP) (Childers, Houston & Heckler 1985). Among the 855, 28 students could be effectively categorized as either verbalizers or imagers (14 respectively) and were selected as the subjects of current study.

Research Tools

Computer Multimedia Software: The multimedia software applied in current study includes the three activities of "Simulation Assisted Statistical Understanding" (called SASU for short) (Liu et al. 2006). This software emphasizes on using the text and diagram simulation to reduce three statistical misconceptions often held by the students(Liu & Lin prepare): (1) Perfect positive correlation means the value of y certainly increases as x increases; and the value of y certainly decreases as x decreases; (2) The correlation coefficient (r) is related to the slope (m); and (3) The coefficient of correlation will change when we change the units of measurement. The interface of SASU contained threes fields: instruction field (presenting texts and figures to explain statistical concepts), simulation field (allowing students to hand on any sample points in the paragraph) and number input field (allowing students to key in or change the correlation coefficient, sample number, and values of two variables)(Fig. 1).

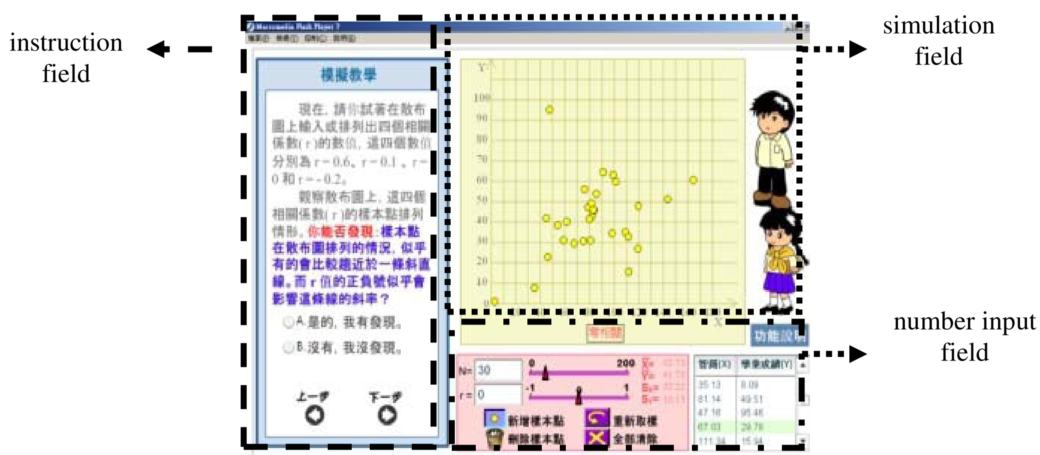

Fig. 1 The frame of SASU

Diagnostic Test about Correlation Misconceptions: Diagnostic Test about Correlation Misconceptions (Liu & Lin 2007) is a standard assessment tool for diagnosing students' correlation misconceptions. The diagnostic test and its equivalent forms were applied in pretest phase, post-test and delayed post-test phase for investigating the variation of subjects' misconceptions in current study.

Procedure

Pretest Phase: Before the 28 subjects started learning with SASU, they were assessed by diagnostic test in order to detect the number of correlation misconceptions they held.

Experiment Phase: Every subject learned with SASU individually and their thinking processes were collected by the think aloud method**.**

Post-test and delayed post-test Phase: The 28 subjects accepted the post-test immediately after learning with SASU for the researchers to understand the variation of students' misconceptions after using the SASU. In addition, the researchers conducted the semi-constructive interviews with subjects on their learning process. To further verify whether the subjects really eradicated their previous misconceptions by learning with SASU, the subjects took part in a delayed post-test three weeks later.

Analysis Phase: This researchers used (1) t test was used to compare whether there were significant differences for the number of misconceptions between the pre-test and the post-test, and between the post-test and the delayed post-test, (2) one-way analysis of covariance (ANCOVA) was conducted with the number of misconceptions of the pre-test as covariate to compare whether there were differences for the number of misconceptions between the two groups of learners (the imager and the verbalizer) in the post-test and delayed post-test respectively, and (3) in terms of the qualitative data analysis, the researchers transcribed the thinking aloud processes, interview, and the notes from the researchers on scene for data analysis and encoding.

Research results

In terms of the learning effects, the analysis results indicated that the average number of misconceptions of the imagers and the verbalizers before using SASU was M=1.42 and M=2.14 respectively. The number decreased after using SASU, with M=0.21 for the imagers and M=0.43 for the verbalizers. In the delayed post-test, the average number of misconceptions for the imagers and the verbalizers was M=0.00 and M=0.64 respectively. Both groups had shown progress in terms of lowering the average number of misconceptions after using SASU, with the results as follows: for the imagers, the number of misconceptions of the post-test (M=0.21) was significantly less than those of the pre-test (M=1.42) ($t=4.32, p<.01$), and the average number of misconceptions of the delayed post-test (M=0.00) was also significantly less than those of the pre-test (M=1.42) ($t=6.28$, $p<.001$); for the verbalizers, the average number of misconceptions of the post-test (M=0.43) was significantly less than those of the pre-test (M=2.14) ($t=6.28$, $p<.001$), and the average number of misconceptions of the delayed post-test (M=0.64) was also significantly less than those of the delayed pre-test (M=2.14) ($t=8.63$, $p<.001$). From the comparison of the both groups, the analysis of covariance indicated that there was no significant difference in the post-test between the two groups ($F=2.77$, $p>.05$). However, in the delayed post-test, the average number of misconceptions for the imagers (M=0.00) was significantly less than that of the verbalizers (M=0.64) ($F=8.33$, $p<.01$).

In the analysis of the learning processes, the data was gathered from the thinking aloud processes and interviews of students. The results showed that the subjects with different cognitive styles would appeared different learning courses based on their preferred approach when processing information. Two illustrations are listed below as the results of the qualitative data analysis.

There were differences for the individuals with different cognitive styles in the ways of their transformation of external representations to mental representations. For example, the imagers tended to transform the text into the image in order to lighten the processing load. The imagers indicated that such transformation helped them to answer more quickly. The following is the example of the transformation way for the imagers according to their preferred approach.

Q: When reading the items, did you keep thinking about the diagrams you just saw?
F15: Yes, I only read the diagram. I had no sense for the text. I just cannot finish reading the text. I would focus on the key points, and numbers, maybe.
Q: So, mostly on the critical points?
(The presentation of the questions includes the diagrams and the text. And the keywords were highlighted in bold.)
F15: Yes. Take the item in the third activity for example, I read the bold text about "Quantity of English Reading" and "Score of Exam", and then I caught the keywords "3 points for one article" and"1 point for three articles" and formed a mental image. *【f15-1】*

There were differences for the individuals with different cognitive styles in the ways of processing the text feedbacks. The verbalizers thought that the text feedback could provide them the directions for thinking, especially when they had discovered mistakes in their thinking. In addition, they would keep the text feedbacks in mind, so that they could inspect this feedback and their own thinking when they encounter the same problems next time to make sure whether their thinking is correct. On the other hand, when reading the text feedbacks, the imagers tended to just verify the correctness of their answers, instead of thinking further to find the root of their mistakes. The following is the response from the imagers and the verbalizers for the assistance of feedback information in the interview.

【Verbalizer】

Q: When did you begin to have this concept that "the correlation is not equal to the slope?"
F1: Um…reading from the *(text)* feedback, but I still didn't quite get it, then I went back to read the diagram.
(After each question, there is the feedback zone that presents a text to conclude the specific statistics concept.)
Q: So, after you entered in the simulation (in the third activity), you then began to think about the relation between the slope and the correlation?
F1: That's right. *【f1-2】*

【Imager】

Q: Did you spend less time reading the (*text)* feedback when your answers were correct？
F11: Yes, I read only those (*feedbacks)* that were marked as "wrong."
Q: How about those marked as "right"? Did you read them as carefully as you read the "wrong" ones?
F11: No. Not really (laughing).
Q: So which part did you read?
F11: Basically, I didn't read a lot (laughing). Just a quick scan to know I was right. *【f11-1】*

Information in the brackets is the supplement information provided by the interviewer to accurately demonstrate the situation.

Conclusions

The results indicated that, both the imagers and the verbalizers could effectively reduce their statistical misconceptions by learning with computer multimedia. Secondly, the imagers could reduce the statistical misconceptions more effectively than the verbalizers after learning through the computer multimedia. Lastly, comparing the average number of the misconceptions of the two groups between the post-test and the delayed post-test, it was noted that the number of misconceptions held by the verbalizers increased slightly, while the number of misconceptions held by the imagers decreased significantly. Therefore, even though there was no significant difference between the number of misconceptions held by the two groups in post-test, there were significant differences in the delayed post-test.

Further analysis of the data gathered during thinking aloud processes and interviews showed that students with different cognitive styles indeed preferred different representations, and subsequently they had different learning processes. For example, the imagers tended to scan the text and only to catch the keywords or numbers in order to reduce the processing load and transform the text into pictures in mind. On the contrary, the verbalizers tended to read the items word by word, and then read the diagram; they seldom transformed the text into pictures in mind. Moreover, the verbalizers could gain more learning effects than the imagers, which helped the verbalizers establish the correct concepts from text.

The results indicated that the students with different cognitive styles did have different preferences and learning stragies. Therefore, the software designers may consider creating different interfaces for learning software to achieve more effective learning for learners in the future. For example, the corresponding diagram representation can be offered accompanied by the text to lighten the cognitive load for the imagers when processing the text, or the explanatory text or important content of professional knowledge can be provided next to the diagram to compensate the shortage of diagram cognition for the verbalizers. In this way, students with either cognitive style can acquire appropriate learning and develop the most optimal learning effects.

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