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TEACHING VARIANCE AND DEGREE OF FREEDOM THROUGH COMPUTER-ASSISTED INSTRUCTION

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ABSTRACT

The principle objective of the current study is to teach variance and degree of freedom by means of computer-assisted instruction. Variance is regarded as one of the most important topics to learn, degree of freedom is a concept considered as one of the most difficult concepts to teach and learn. The preliminary results on 15 faculty members showed that they had limited knowledge related to these concepts. Based on this need analysis, we developed a video tutorial to teach these concepts using Flash and Camtasia Studio software. We also considered visual design and instruction principles when developing the tutorial. The tutorial is made up of three parts: population variance, degree of freedom and sample variance. The effectiveness of our tutorial was tested on these 15 faculty members. The findings revealed substantial improvement in their knowledge about these two concepts. They were very satisfied with the tutorial and gave us valuable insight into what can be done to promote the instructional value of our tutorial. We strongly believe that the video tutorial we developed has a great potential to help learners of statistics to grasp these concepts.

Key Words: Variance, degree of freedom, statistics learning, computer-assisted instruction.

INTRODUCTION

Multimedia can be defined as the presentation of knowledge as a combination of words and figures (e.g. video). Research studies showed the positive effects of multimedia on learning (Mayer, 2007). For example, Plasschaert, Cailleteau, Ernie (1997) found the positive effects of multimedia interactive tutorial on learning endodontic problem-solving in the field of medicine. Lloyd and Robertson (2012) examined the role of screencast tutorials on enhancing student learning of statistics. Screencasting can be defined as capturing what is done on the computer screen with synched audio commentary (Udell, 2004). These researchers found that after controlling for previous math experience, math and computer anxiety, screencast tutorials were effective in promoting student learning of statistics.

There is empirical evidence that multimedia (specifically videos) is a beneficial tool that helps people learn statistics. Our paper is aimed at developing a screencast video tutorial that teaches two important topics in statistics: variance and degree of freedom. Many researchers agree that concept of degree of freedom is a difficult concept to teach and learn (Everett , 2002). The difference between sample and variance can be understood in the context of degree of freedom. Everett (2002) explained how difficult concept degree of freedom is by saying “Degrees of freedom: An elusive concept that occurs throughout statistics” (p.111). Eisenhauer (2008) gave a good real life example to explain the degree of freedom. Suppose that there are three tasks required to be finished, which are nap, eat and read. Each task lasts 1 hour. We are required to schedule these tasks from 1 to 4 PM. We are not completely free in doing this. If we decide to eat at 1 PM, read at 2 PM, we are not free to choose the time of nap. It has to be at 3 PM. In this example, the degree of freedom is 3-

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1=2. That means, the time of one task is not free to vary. Degree of freedom can be defined as the number of observations which are free to vary (Schwartzman, 1994).

METHOD

Participants

The participants consisted of 15 faculty members from 5 different departments (4 instructional technology, 4 biology education, 3 music education, 2 science education, 2 early childhood education). 7 of the participants were female, 8 were male. The participation was voluntary.

Research Instrument

The data collection tool consisted of open-ended 7 questions. 2 of the questions were related to degree of freedom. The remaining questions were concerned with variance and deviation. Questions included:

1) What do you understand from variance? Give an example.
2) Variable X1 has values of 3, 4, 5 Variable X2 has values of 2, 4, 6. Which variable seems to have a higher variance? Explain your response.
3) The variable X has values of 1,3,5,7 and 9.

a) Calculate the variance of X if these numbers come from a population?
b) Calculate the variance of X if these numbers come from a sample?

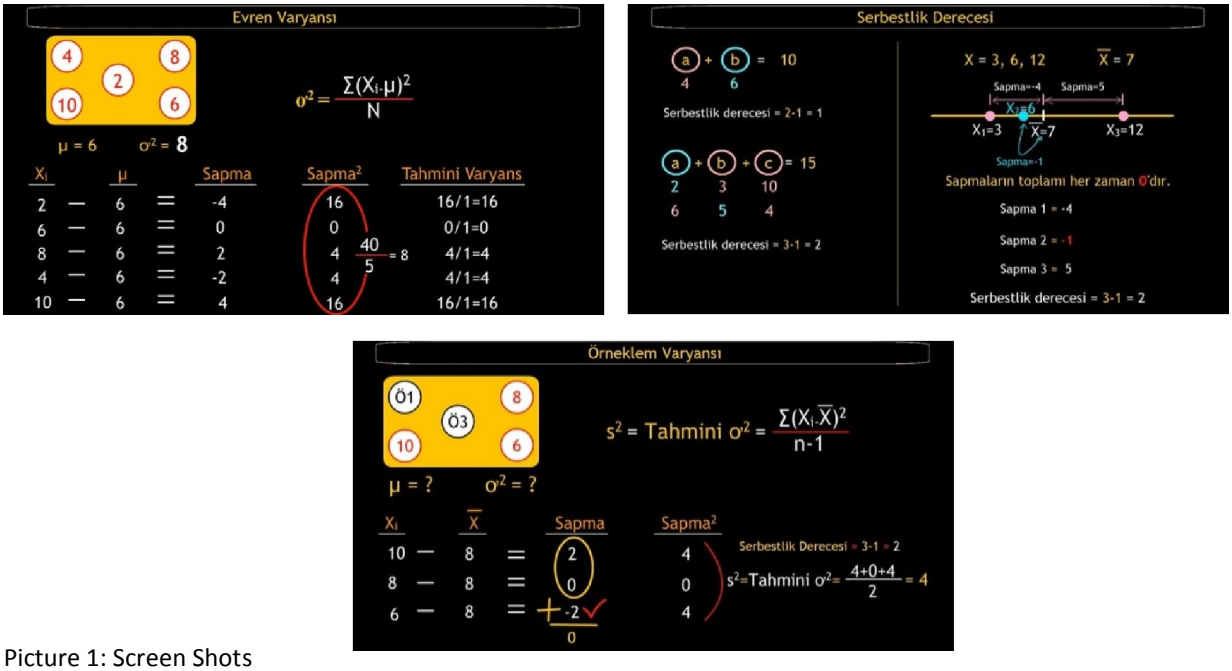
4)

a) What do you understand from degree of freedom in statistics? If possible, give an example.
b) One researcher wants to estimate the mean score of 1000 students in an exam. To meet this purpose, he collected data from 25 students? What is degree of freedom in this example?

5) There are three observations in the variable X. The first observation is -2 units away from the mean. The second observation is -1 unit away from the mean? What is the deviation of third observation?

Video Tutorial

A video tutorial aimed at teaching variance and degree of freedom to learners was developed for this study. It is made up of 3 phases. The first step is about teaching population variance. The second step is aimed to provide the learners with a conceptual understanding of degree of freedom. The third step teaches sample variance. All of these steps were thought in separate pages. Picture 1 shows the screen shots of these three pages.



Picture 1: Screen Shots

Data Analysis

Data for this study were collected through pretest, posttest, interview and observations. Descriptive statistics including the number of questions answered correctly in pretest and posttest were provided. This analysis allowed us to examine the improvement of faculty members' knowledge with regard to variance and degree of freedom. Interview questions included "What do you think about this software in terms of learning?", "Do you have any suggestion to improve the instructional value of this tutorial?", and "Did you understand the logic behind the calculation of variance and standard deviation?"

FINDINGS

Pre-Test Observations

When we asked the faculty members to define variance, 5 of them were able to answer it correctly. 2 of them said that variance is the square root of standard deviation. This showed that they know that there is a relationship between variance and standard deviation. However, they failed to give the correct answer. The correct answer was: standard deviation is the square root of variance. One faculty member wrote down the formula of sample variance. Another faculty member said that variance is the number which is repeated most. The other faculty member said "I heard variance 1000 times; however, I do not know what it means".

When they were asked what they understand from degree of freedom, none of the faculty members knew what degree of freedom is. Only one faculty member said it is n-1; however, he said he had no idea why it is used in statistics. 3 of the faculty members were able to correctly answer the question which requires the use of formula n-1 to find degree of freedom. 4 faculty members were able to correctly answer the question regarding deviation.

In general, faculty members who showed poor performance in the pre-test attributed their failure to several reasons listed below.

- "We took a number of statistics course. But, everything has been forgotten."
- "I learned these concepts in my PhD. I do not remember now"
- "I get help from my colleagues who knows statistics when I am required to use statistics"
- "I do not know these topics; however I am very enthusiastic about learning them."

3 of the faculty members took the pragmatic approach. They were not willing to watch the tutorial at first. Their responses included:

- "What am I gonna do with learning these topics? There are statistical packages that help me calculate variance and standard deviation."
- "I do not know these topics very well. However, if I want, I can learn them using the Internet"

One faculty member said "I do not have sufficient capabilities to learn these concepts. Although I have never seen the video you prepared, I strongly believe that I can't do it". When we were in one of the participants' office for his study, his colleagues came to the office. Although we did not invite him for his study, he wanted to be a participant in this study.

Post-Test Observations

After watching the video tutorial, the opinions of two faculty members who had pragmatic views have changed drastically. One of them said: "I got a good understanding of these concepts after seeing the video. I was able to clarify some misconceptions regarding these concepts". This faculty member was able to answer all of the questions correctly and gave his own examples related to variance and degree of freedom. The other faculty member who initially had pragmatic approach said:

"Frankly, I searched these topics after the pre-test. I understood that I had misconceptions about variance. I thought variance is the square root of standard deviation. However, the opposite was true. Although I looked

at many websites explaining degree of freedom, none of them enabled me to learn it. However, your video was perfect in that it explained me degree of freedom in simple, easy and comprehensible ways".

The faculty member who was not able to answer none of the question in the pre-test watched the video without stopping. He was the only faculty member who watched the video without stopping. This person answered all of the questions correctly in the post-test and gave his own examples related to variance and degree of freedom. He further indicated that degree of freedom was not as difficult as he thought. The faculty member who had very low self-efficacy learning new statistical concepts still struggled to answer the questions after seeing the video.

One of the faculty members found the instructional strategy used in the tutorial interesting. He said:
"In Turkey, we give the definition of the concepts first. Then, we give an example related to those concepts. This tutorial does the opposite. It gives an example first. Then it gives the definition of variance. This manner is interesting to me. Since professor Serkan took his PhD in the USA, I think you designed this tutorial in this manner. Although this way of teaching seems to be fine, I think before you start explain what the variance is by giving examples, you first need to explain why variance is an important concept in a scientific research".

Table 1: Results of Pre-Test and Post-Test

Questions	Pre-Test	Post-Test
Q1	6	15
Q2	3	13
Q3-a	2	11
Q3-b	2	11
Q4-a	1	13
Q4-b	2	14
Q5	3	14

Table 1 shows the results of pre-test and post-test. The results showed that there has been dramatic increase in their performance. Almost all of the participants showed a good understanding of the concepts of variance, deviation and degree of freedom; however, 4 of the faculty members were not able to calculate the population and sample variance. Although these people were able to grasp what variance, deviation and degree of freedom, they had difficulty when it comes to calculation. When we asked them about this issue, they said that their mathematics is not good.

DISCUSSION

The main purpose of this study was to develop a video tutorial aimed at teaching the topics of variance and degree of freedom to faculty members. Our main intention was not to enable them to learn how to calculate variance; however, our tutorial was designed to provide them with a deep conceptual understanding of variance and degree of freedom. The results, in general, revealed that the participants liked the tutorial, found it instructive, beneficial and easy to follow. They indicated that they learned something new and the topic of degree of freedom was not as difficult as they thought. Some of them were able to give an example related to the applications of variance in their field. It seems that using multimedia has beneficial effects on the faculty members' learning of some statistical concepts as well as it happens in other fields (Mayer, 2007).

As it has been mentioned in the introduction, degree of freedom is a difficult concept to learn and teach in statistics (Eisenhauer, 2008). Our tutorial appeared to be effective in teaching this concept to the faculty members; however, 5 participants still had difficulty with getting a deep conceptual understanding of this topic. We observed that these participants mostly do qualitative studies in their research and have a poor background of mathematics and statistics. We think that giving more examples regarding the applications of degree of freedom in real life might enable such faculty members to grasp this difficult concept. Although some participants seemed to struggle to understand degree of freedom, all the participants learned what variance is,

difference between sample and population variance and the relationship between variance and standard deviation.

In sum, our observations in this study revealed that the faculty members had little or no knowledge of variance in the pre-test; however, the overwhelming majority of them showed a high performance in the post-test, which suggested that the video tutorial we designed had beneficial effects on their learning of this topic. Therefore, we believe that statistics teachers can use confidently utilize this tutorial in their classroom while teaching these concepts. In addition, this tutorial can be used as a self-paced learning tool by learners of statistics.

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