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A Comparative Study of the Effect of Two Methods of Online Education Based on Sweller'S Cognitive Load Theory and Online Education in A Common Way on the Academic Engagement of Medical Students in Anatomy

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Abstract

Background: One of the most important indicators of the quality of education and academic achievement is students' academic engagement, and the progress of using online education has fundamentally changed the learning-teaching processes Therefore, the aim of this study was to compare the effect of two methods of online education based on Sweller's cognitive load theory and online education in a conventional method on the academic engagement of medical students in anatomy.

Methods: The present study was a quasi-experimental study with two groups not identical to the before and after design. To collect information, the Shuffle and Becker academic engagement questionnaire with Cronbach's alpha of 0.85 was used. The subject was 104 basic science students. General medicine students were divided by non-random method into two groups of intervention (n = 52) and control (n = 52). After the intervention, a post-test was taken. After collecting data, this data was entered into SPSS software version 24.

Results: The results of the independent t-test showed that there is a statistically significant difference between the mean scores of academic engagement in the control and intervention groups after the intervention and also, the results of the dependent t-test showed that online teaching of anatomy course based on Sweller's cognitive load theory has a positive and significant effect on medical students' academic engagement.

Conclusion: Considering the results of this study and the significant effect of online education based on cognitive theory, it is suggested that teachers and educators be educated about the basic principles of load cognitive theory so that they can apply these principles due to the limited capacity of active memory.

Keywords: Teaching, Online Learning, Cognitive Psychology

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Introduction

Academic engagement is the quality of effort that students spend on active educational activities to directly achieve better results. This variable includes all the processes with which a person is engaged in doing a task.

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↑What is "already known" in this topic:
In educational studies, Sweller's cognitive load theory has been used in face-to-face teaching, but in this study, we compared the effects of two methods of online education based on Sweller's cognitive load theory and traditional online education on the academic engagement of medical students.

→What this article adds:
In this study, we came to the conclusion that online education based on Sweller's cognitive load theory can increase students' academic engagement.

Academic engagement includes behavioral, cognitive, and motivational dimensions (1). The behavioral component of academic performance refers to actions that can be seen in the classroom, such as making an effort and persevering through difficult homework issues or seeking assistance from peers or instructors in order to acquire and comprehend the course material. The learner's emotional responses in the classroom are referred to as the emotional dimension of conflict. Cognitive engagement includes all kinds of processing processes that students use for learning and consists of cognitive strategies and metacognitive strategies (2).

Cognitive load theory, one of the theories related to information processing, has provided a framework for designing multimedia educational materials. Cognitive load in psychology refers to the mental efforts consumed in active and limited memory (3). According to the basic premise of this theory, learners have a minimal working memory capacity for processing when faced with new information. Accordingly, the mental load resulting from the educational content beyond the limited capacity of the learner's active memory will disrupt his learning. The reason for the ineffectiveness of many multimedia educational materials is their disregard for the limitations of the human information processing system, especially the limitation of the active memory processing capacity (4).

Several studies have been conducted to investigate the impact of electronic educational design based on Sweller's cognitive load theory, such as Cronbach et al. (2017) in Germany at the University of Saarland under the title of measuring cognitive load in electronic learning using a two-group experimental method. This study aimed to investigate the effect of online education based on the theory of cognitive load on learners' academic engagement and knowledge. In this research, the index of cognitive engagement and activity of people was measured during electronic learning. The results of this research showed that the cognitive load theory and its design principles in electronic as well as online education cause more cognitive involvement and learning activities in learners (5). Pau et al. (2019 studied cognitive load control with the method of divided attention effect in the Netherlands. This research was conducted experimentally in two groups, pre-test, and post-test, and on 52 samples of Dutch university students with two educational methods. The results showed that using pictures and presenting words orally significantly affects students' learning compared to when pictures are presented along with text (6).

One of the practical implications of cognitive load theory is using cognitive load effects in educational design to increase learning efficiency. Cognitive load effects include worked example effect, completion problem, modality effect, attention split effect, expertise reversal effect, redundancy effect, and guidance fading effect. The worked example effect is a technique that reduces external cognitive load by replacing practical exercises with a set of solved examples (7). Anatomy is essential for medical students because of its value in paraclinical and medicine. Most students consider this course one of the most difficult due to many terms and knowing the position of the organs and their proximity in the body. The teaching method, like other introductory medical science courses, can be very effective in increasing student learning in teaching anatomy (8). Many studies have pointed out the relationship between online learning and cognitive load theory, but the effectiveness of this theory has been limited in comparing the common online teaching method in anatomy. Considering the importance of anatomy courses for medical students, it is possible to use cognitive load theory in teaching this course in case of the effectiveness of online anatomy courses based on cognitive load theory on students' academic involvement. Therefore, this study was conducted to compare the effect of two online education methods based on Sweller's cognitive load theory and traditional online education on the academic engagement of medical students in anatomy.

Methods

The research method was quasi-experimental with two intervention and control groups, with a pre-and post-design, and was conducted in 2022 at the Iran University of Medical Sciences, and its population included Basic Science students of the General Practitioner Department of Iran University of Medical Sciences.

General practitioner in Iran includes a 7-year academic course and consists of 4 levels of Basic Science, physiopathology, internship, and clinical internship. Students must pass about 290 course units during this period. The basic science course consists of five academic semesters, upon completion of which, students can enter the next course, which is physiopathology, and after that, the medical science comprehensive exam is held.

The sample population included all students of basic medical sciences ،104 basic science medical students were selected and then divided into two control and intervention groups (52 in each group) .A pre-test was taken from both groups two weeks before the intervention with Shefli and Becker's academic engagement questionnaire. This tool has nine items and three components (ability, commitment, and attraction) with a 5-point Likert scale, and each item has a value between 1 and 5. This tool was standardized by Seif et al., and professors and experts in this field confirmed the validity of the questionnaire. In addition, the reliability of the questionnaire was obtained using Cronbach's alpha above 0.85 (9). Both the intervention and control groups received their training online. Based on Sweller's cognitive load theory, the intervention group received three online training sessions on the anatomy of the digestive system in the Big Blue Button software platform. For the control group, three online training sessions on the digestive system anatomy were conducted in the Big Blue Button software platform and the usual way. According to the principles of Sweller's cognitive load theory, an educational multimedia on the anatomy of the digestive system of general medicine students was prepared for the intervention group. Things that might lead to students' distraction (including screen color, extra lines, noise, and extra content) were avoided. Two auditory and visual senses were used simultaneously, and it was avoided to present complex and extensive content that

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would be difficult to understand. The content was presented simply, avoiding giving repetitive information and using practical examples (primarily related to students' daily life), varied and extensive. Both groups answered the academic engagement questionnaire two weeks after the educational intervention. The data was entered into SPSS software version 24 and analyzed using descriptive and inferential statistics after collecting the data. Chi-square test and t-test were used to check the homogeneity of the two control and intervention groups in terms of age and gender and parametric t-tests were used to compare the average scores considering the normality of the total academic engagement.

Results

The mean and standard deviation of the age of the participants in the research was 27 ± 4, respectively (36% male and 64% female). Researchers check the homogeneity of the two control and intervention groups in terms of age and gender. The results did not show significant differences between the two groups. This result indicates that the two groups were homogeneous regarding demographic characteristics.

Also, comparing the components of academic engagement (including ability, commitment, and attraction) in the two intervention groups and the control after the implementation of the intervention also showed that the average scores of these components were higher in the intervention group (Chart No. 1).

Comparing the average score of academic engagement before and after the intervention in the control group showed that the average academic engagement before the intervention in the control group was 20.5, and after the intervention was 21.1. There was no significant difference between the average academic engagement scores before and after the intervention in the control group ($P = 0.476$). Comparing the average score of academic engagement before and after the intervention in the intervention group showed that the average academic engagement before the intervention in the intervention group was 21.5, and after the intervention was 30. There was a significant difference between the average scores of academic engagement before and after the intervention in the intervention group ($P < 0.001$) (Table 1).

Comparing the average score of academic engagement before the intervention in the two study groups showed that the average academic engagement before the intervention was 21 in the control group and 21.5 in the intervention group. No significant difference was observed between the average academic engagement in the two groups. Comparing the average score of academic engagement after the intervention in the two study groups showed that the average academic engagement after the intervention was 20 in the control group and 30 in the intervention group. There was a significant difference between the average academic engagement in the two groups after the intervention ($P < 0.001$). The result showed a significant difference between the average scores of academic engagement before and after the intervention in the intervention group ($P < 0.001$). Therefore, the research hypothesis is confirmed, and the null hypothesis is rejected based on no difference between academic

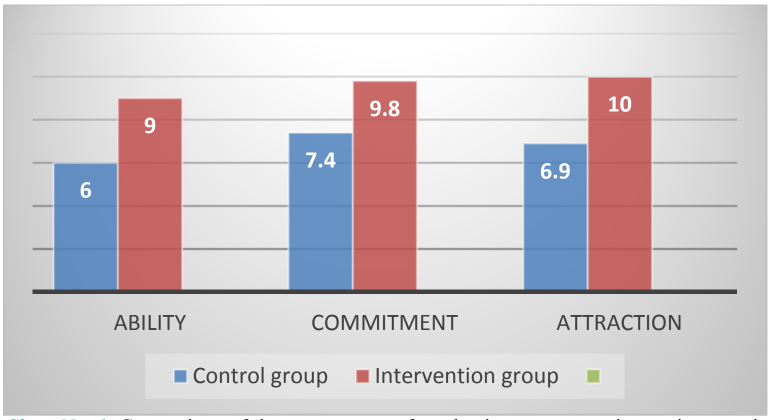

Chart No. 1. Comparison of the components of academic engagement in two intervention groups and control after the implementation of the intervention

Table 1. Comparison of the average score of academic engagement in two control and intervention groups before and after the intervention

Group	Intervention	Average academic engagement	SD	Mean differnce	*P* Value
Control	Before the intervention	21	4.6	-0.78	0.471
	After the intervention	20	5.6		
Intervention	Before the intervention	21.5	4.6	9	< 0.001
	After the intervention	30	4.5		

Table 2. Comparison of the average score of academic engagement before and after the intervention in two control and intervention groups

Intervention	Group	Average academic engagement	SD	Mean difference	*P* Value
Before the intervention	Control	21	4.6	-0.78	0.471
	Intervention	20	5.6		
After the intervention	Control	21.5	4.6	9	< 0.001
	Intervention	30	4.5		

engagement scores before and after the intervention group intervention (Table 2).

Discussion

The results showed that the online teaching of anatomy courses based on Sweller's cognitive load theory had a positive and significant effect on the academic engagement of medical students. Using online education based on Soler's cognitive load theory leads to students showing more desire during the learning process. As a result, educational techniques should be planned in line with the main principles of the human cognitive system. These results are in line with those of Olino et al. (10), Chang (11), Chen and Hu (12), Mousavi et al. (13), and Cronbach et al. (5). The central premise of cognitive load theory is an educational design based on the characteristics of human cognitive structure, showing that the limitations of human working memory should be considered during training (14).

Sweller's cognitive load theory reduces cognitive load, improves mental performance, and enhances the attitude to learning. Thus, learners mobilize all their energy and internal resources for learning, ultimately causing more involvement of learners with learning experiences (15). The independent t-test showed a significant difference between the average scores of academic engagement in the control and intervention groups after the implementation of the intervention. This result was consistent with that of Mohammad Obeid et al. (16), Pau et al. (6), Sweller et al. (17), and Kiano (18).

Since, in this research, the teaching method was optimized with the cognitive capacity of the learners, the educational activities led to better performance and learning in the experimental group. In many pieces of training, the limitations of the human cognitive structure are not considered accurately and correctly. Learners simultaneously use visual and auditory senses to receive the material, which causes additional cognitive load and reduces learning. Using the principle of sensory channels, Sweller's cognitive load theory proposes a separate auditory and visual channel for entering information into working memory and describes a way to deal with the conditions of attention division. For example, instead of simultaneously presenting an image and written text, which relies on the visual channel and causes the division of attention, it is recommended to use an image and oral text, which rely on the visual and auditory channels. Further, learners are exempted from paying attention to materials unrelated to the learning objectives and use their cognitive capacities to learn the central and essential materials by using the principle of redundancy (11). Meaningful learning occurs when the learner is genuinely engaged in the cognitive process of learning, yet the learner's capacity for cognitive processing is severely constrained. Cognitive load is a key component of multimedia instructional design. Therefore, education based on cognitive load effects increases learning results and minimizes external cognitive load. Designing educational environments based on the effects of cognitive load, which is optimized based on active learning, makes learners understand the value of learning and trust their abilities to learn and progress with acceptable effort.

Conclusion

Based on the results, it is recommended to use the principles of cognitive load theory in online education to improve the learning process and increase learners' academic engagement, given the significant effect of online anatomy training based on cognitive load theory.

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Code of Ethics

This study was approved by the ethics committee in research of Iran University of Medical Sciences with the code of ethics IR.IUMS.FMD.REC.1400.523.

Conflict of Interests

The authors declare that they have no competing interests.

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