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Comparison of e-learning and the classroom lecture in a microbiology course based on Gagne's instructional model

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Abstract

Introduction: This study aims to design and produce electronic content of a microbiology course for students in AJA (Islamic Republic of Iran Army) University of Medical Sciences based on Gagne's instructional design model and determine its effectiveness.

Methods: This is a quasi-experimental study. All medical students studying in the 2014-2015 academic year in AJA University of Medical Sciences who had taken the microbiology course were entered in the study. Students were divided randomly into two groups, control and trial (16 subjects in each). After designing and producing the educational multimedia, the trial group was trained in concepts of the microbiology course using multimedia educational software during 6 sessions over 6 continuous weeks. Finally, they were given post-test questions to determine the educational progress level among the students.

Results: The mean ± standard deviation (SD) for pre-test and post-test in the trial group were 4.44 ± 1.99 and 12.75 ± 1.06, respectively, and in the control group they were 3.75 ± 2.32 and 9.31 ± 1.25, respectively. The results of the analysis of covariance between adjusted means of both groups for variable of learning show a significant difference between the two groups ($F[29,1] = 65.69$; $P=0.001$). The effect size was 0.69.

Conclusion: The multimedia software produced in AJA University of Medical Sciences can be used as a proper educational instrument for teaching the microbiology courses. So, it is better to incorporate the multimedia method as a part of education into curriculum of universities, especially medical sciences universities.

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Introduction

The 21th century is the century of societies' movement towards knowledge centeredness, knowledge sharing and evolution in basic concepts and dimensions of life, such as education and training.[1] The development of access to appropriate hardware and software for electronic learning, especially the development of the World Wide Web, has opened up a new window for educational institutes. It seems that the use of these facilities for training can help to realize some goals that are considered as criteria for training quality such as learner centeredness, active learning and interactive learning. Given the general advantages of electronic learning and its special capabilities in medical education, it seems inevitable to merge e-learning into current educational programs.

Training is provided through various methods, and one of them is training via multimedia software and electronic content, which is considered one type of e-learning. E-learning is one of the most well-known environments for teaching and learning.[2] In addition to the providing rich educational content,[3,4] e-learning plays an important role in the sustainable development of the information society[5] and educational systems in different countries.[6] To properly design electronic content, a process through which the learning, not the technology, is put at the center of the development of training should be utilized.[7]

One important point is that the efficiency and effectiveness of e-learning depends on flexible instructional design of electronic content and adherence to educational standards required for designing them.[8] Hence, in order to

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develop the electronic content of curriculum, new methods and frameworks for providing educational materials should be considered.[9] In the e-learning environment, providing content via text, sound, pictures, video, animation and simulations describing real life situations is very important. Also, providing experience-based learning and teaching in accordance with the environment can result in more attractive provision of lecturers' contents and meaningful learning, especially in some courses not related to the daily lives of learners.[10] Thus, the production and management of educational content appropriate to learners' social, psychological and educational characteristics, considering their interests, study styles and knowledge levels[11] and how to provide high quality, updated and renewable educational content[12] are among the most fundamental concerns in electronic learning. Furthermore, the issue of improving the quality of medical education has always received attention and becomes more important day to day. In teaching topics of medical sciences courses, there is a growing trend to replace traditional teaching with electronic courses.[13]

Given the increased number of applicants to study at medical universities and higher education institutions, as well as the barriers to studying for these applicants, providing the opportunity to study at any time and place has become one of the concerns of education authorities.[14] So, one solution in this regard is to apply instructional design achievements in the design and production of electronic content in e-learning systems. Since universities of medical sciences have the responsibility of training skilled and expert human resources in addition to providing health care services, medical education must be continuously reviewed and improved using instructional design patterns. Student, teacher, education, educational content, teaching methods, educational resources and the growing trend of educational technologies and e-learning are among these factors.

Moule et al investigated aspects of implementing e-learning in health and nursing sciences majors and factors affecting its application. They mentioned that despite many recommendations for the use of e-learning, this issue is unknown in the area of health and nursing sciences and few studies have been done on its acceptance by higher education institutes.[15] Chou et al, in a study titled "An experimental study of outpatient health education needs and effectiveness of e-learning" investigated the impact of the use of e-learning regarding educational needs of outpatients with the emphasis on health education as an important item in management of diseases. The results indicated that most of the patients (72%) gave positive feedback about e-learning for health education.[16] In a study titled "Strategies for the development of training in content production," Fuchsberger stated that incorporating e-learning into training is currently inevitable, and also introduced the electronic content scheme with the aim of developing high quality e-content.[17] A study conducted by Bati et al showed that both multimedia and traditional learning are effective in increasing the level of students' knowledge; however, the level of knowledge in multimedia-based learning is significantly higher.[18] Fani et al conducted a study titled "The comparison of the impact of traditional education method (class learning) and modern education method (multimedia) on knowledge and satisfaction among dentistry students" aimed at comparing the two education methods of traditional and modern multimedia. The results showed that there is a significant difference between mean score of satisfaction and learning among the two methods.[19]

Thus, given the important role of education in the production process of electronic content, especially in the field of medicine, this study aims to design and produce electronic content of the microbiology course for students in AJA (Islamic Republic of Iran Army) University of Medical Sciences based on Gagne's instructional design model, and determine its effectiveness.

Materials and Methods

This is a quasi-experimental study. All medical students studying in the 2014-2015 academic year at AJA University of Medical Sciences are the statistical population of the study. Since the course of microbiology is provided once in each semester, and given that students who had taken the microbiology course were required for implementing the designed electronic content, the convenience sampling method was used. Medical students (32 individuals) who had taken this course were selected as the sample and entered in the study, and also were randomly assigned to one of two groups of control (16 individuals) and trial (16 individuals).

To collect the data, a pre-test and post-test were used as described below:

A) Pre-test on learning: This test consisted of 15 multiple-choice questions designed by the researcher under supervision of the supervisor and advisor professors. The students took the test before implementation of the independent variable (electronic content of the microbiology course based on Gagne's instructional design). A correct answer received a score of 1 and the wrong answer received a score of zero (a total of 15 points).

B) Post-test: In this study, pre-test and post-test questions were developed parallel to each other. In other words, the questions of post-test on learning were developed parallel to pre-test on learning in terms of type, number and the level of difficulty of questions.

The content validity and face validity of the pre-test and post-test were approved by the supervisor and advisor professors. For measuring the reliability of the test, the Kuder-Richardson method was used. Due to the use of parallel questions in the pre-test and post-test, the reliability of the pre-test was measured at 83%.

Due to the lack of educational multimedia (electronic content of the microbiology course based on Gagne's instructional design) for teaching concepts of the microbiology course, researchers decided to design and produce educational multimedia (electronic content) for this

group of students. As a result, they initiated the design and production of educational multimedia (electronic content) using audio-video media, especially film and animation, attracting more attention based on the principles of Gagne's instructional multimedia design and principles of producing electronic content, and also using the opinions of the supervisor and advisor professors.

It took three months to design and produce educational multimedia called "Electronic content of the microbiology course based on Gagne's instructional design" by the researcher.

After the confirmation by the supervisor and advisor professors and justification of the professor of the microbiology course in the medical school regarding the topic and methods of conducting the study, the pre-test on learning was conducted among both groups. Then, one group was randomly assigned to the control group and another group was assigned to the trial group. During 6 sessions over 6 continuous weeks, the trial group was trained in concepts of the microbiology course using multimedia educational software (electronic content). Table 1 shows details of the sessions of electronic content programs. After training the students, they were given post-test questions to determine the educational progress level among the students.

Statistical analysis

Descriptive statistics (mean and standard deviation) in terms of the pre-test and post-test for the trial and control groups and the whole sample were used to analyze the data. Also, in order to compare the two groups in terms of obtained mean score in learning on the tests at the level of inferential statistics, the analysis of covariance was used. The Kolmogorov–Smirnov test for checking the normality of the learning variable in both groups was used.

Results

Descriptive statistics

According to Table 2, the mean ± standard deviation (SD) for pre-test and post-test in the trial group were 4.44 ± 1.99 and 12.75 ± 1.06, respectively, and in the control group they were 3.75 ± 2.32 and 9.31 ± 1.25, respectively.

As it is seen, the mean of the post-test for the trial group (12.75) is higher than the mean of this test in the control group (9.31).

Analytical statistics

In order to compare both trial and control groups in terms of obtained scores from the desired test, the analysis of covariance was used. The results of the Kolmogorov–Smirn-

Table 1. Details of the sessions of electronic content programs

Session	Training issue	General purpose	Comments
First	Bacterial Genetics	• Understanding the genetics of bacteria • Understanding the definitions and terminology in bacteria • Understanding the complex genetic elements (DNA) of bacteria	To enter and engage students in the learning process, the image of the bacteria, broadcast film and animation related to the bacteria has been shown and then through Gagne instructional design principles will be taught other topics. During the training, the multimedia software gives the feedback to the students.
Second	Recombination in bacteria	Understanding Recombination and the major mechanisms of recombination in Bacteria	The purpose of these sessions is recombination in bacteria based on Gagne's instructional design model. First slide with a picture and a movie starts and then major mechanisms of recombination in Bacteria are taught. After teaching for better learning, multiple choice tests are used and at the end, the issues will be summarized.
Third	The genus Actinomyces	Understanding the physiological, antigenic and epidemiological characteristics of the members of the genus Actinomyces and Nocardia as well as knowledge of diseases and disorders with symptoms and ways to detect, control and treat infections caused by them	The purpose of this session, is teaching Actinomyces and Nocardia. To enter this discussion, at first the definition and categories of Actinomycetes should be described and then genus Nocardia and its variants will be taught. At the end, the variants of Actinomyces are presented in the form of multimedia.
Fourth	The genus Yersinia	Understanding the physiological, antigenic and epidemiological characteristics of the members of the genus Yersinia, as well as members of the genus Fransysla as well as familiarity with clinical signs and symptoms of disease, as well as methods of diagnosis, management and treatment of infections caused by them	The purpose of this session is teaching the general characteristics of the genus Yersinia and its important species. To enter this discussion, a picture of Yersinia was used and then plague topics, types of plague, tularemia and its types were discussed. During teaching, for better learning, multiple-choice tests was used.
Fifth	Evaluation	Assessment of learning	After the training of e-learning content of microbiology, to inform students of the learning level and better learning, multiple-choice tests was used.
Sixth	Conclusion and implementation of the post-test learning	The final conclusion of electronic content taught and performing the post test	In this session, the students were given a post-test to determine if progress has been made or not?

Table 2. Descriptive information of learning measurement according to the assessment stage in the groups

Factors	Statistical indicators	Pre-test	Post-test
Trial group	Number	16	16
	Mean	4.44	12.75
	Standard deviation	1.99	1.06
	Adjusted mean	-	12.74
Control group	Number	16	16
	Mean	3.75	9.31
	Standard deviation	2.32	1.25
	Adjusted mean	-	9.31
Total	Number	32	32
	Mean	4.09	11.03
	Standard deviation	2.16	2.08

Table 3. Variance test for checking homogeneity of regression slopes in both groups for variable of learning

Statistical indicator	Total squares	df	F	*P*
Group	17.57	1	12.18	0.002
Pre-test	0.036	1	0.025	0.786
Group* Pre-test	0.023	1	0.016	0.899
Error	40.38	28		
Total	4029.00	32		

ov test for checking the normality of the learning variable in both groups show that the assumption of normality of the dependent variable (learning) in both trial and control groups was proved at the significance level of more than 0.05.

Levene test for checking the homogeneity of variances in both groups for the variable of learning is confirmed with F (1,30) = 1.06 and the significance level at 0.310 ($P > 0.05$). As Table 3 shows, variance test for checking homogeneity of regression slopes in both groups for variable of learning was confirmed with F(1,28) = 0.016 and the significance level at 0.899 ($P > 0.05$).

According to Table 4, the results of the analysis of covariance between adjusted means of both groups for variable of learning with F (1,29) = 65.69, the significance level at 0.001 and with 99% confidence interval show a significant difference between the two groups ($P < 0.01$). The adjusted mean for post-test in the trial group was 12.74 and in the control group was 9.31; the mean of the trial group was higher than that of the control group. Thus, there is a significant difference between those students who were trained using the designed electronic content (educational multimedia) compared with those trained using the traditional method. The independent variable with the effect size of 0.69 can predict the variable of learning and the power of the test is 1.00.

Discussion and Conclusion

The present study aimed to design and produce electronic content for the microbiology course for students in AJA University of Medical Sciences based on Gagne's instructional design model and determine its effectiveness.

Studies conducted by Moule et al[15] and Chou et al[16] indicate the impact of multimedia learning (electronic content) on the increase of learning and knowledge among students. These studies have mentioned practical aspects of using multimedia software for producing electronic content, including facilitating teaching by professors, increasing student learning, conveying concepts and content through easier, broader and more attractive use of text, video and audio.

This study showed that the level of students' learning using multimedia and electronic content methods was significantly different from merely lecturing and stating theories. The students' interest in the microbiology course and the retention duration of the learned information increased by using film, music and animation. Also, active participation of the students in learning and teaching was observed.

One of the fundamental issues regarding electronic learning that seems necessary to address is the quality of the process of design, development and provision of electronic education.[20] Researchers who work in this field have various opinions about the quality of e-learning programs. While many of them believe that e-learning education programs have not been able to act based on quality standards determined by institutes for these programs, others have defended these programs and considered them to be high quality. They mention various factors influencing the educational quality of these programs, such as institute, the technology in use, supporting systems, program structure and content and educational design.[21] Among the mentioned factors, it seems that paying attention to the structure and quality of producing educational content is one of the most fundamental issues in e-learning. The development of electronic content based on educational design patterns is one of the main challenges of e-learning and the secret for success of this educational system. The educational content is part of data with specific components and relations between them that have been prepared with the aim of improving the level of knowledge and skill of a learner. Since there is a significant relationship between the use of strategies and techniques for designing electronic content and educational multimedia with learning and motivation among medical sciences students, it seems necessary that organizations and universities pay special attention to design and apply scientific approaches in this regard. The multimedia software produced in

Table 4. The results of the analysis of covariance between adjusted means of both groups for variable of learning

Variables	Total squares	df	F	*P*	Effect size	Power of test
Pre-test	0.028	1	0.020	0.88	0.001	0.052
Group	91.53	1	65.69	0.001	0.69	1.00
Error	40.40	29				
Total	4029.00	32				

AJA University of Medical Sciences showed that it can be used as a proper education instrument for teaching the microbiology courses. Furthermore, the use of Gagne's instructional design model in producing multimedia and electronic content for this course has been investigated for the first time in Iran. It is better to conduct research in the same field in organizations, various medical specialties and paramedical majors, so that the generalization of results can be possible and strengths and weaknesses can be identified. It should be noted that the results from the evaluation was used for the next versions of the program. Hence, given the impact of multimedia-based education on learning without decreasing satisfaction level and retention among students, it is better to incorporate this method as a part of education into curriculum of universities, especially medical sciences universities.

Ethical approval

This study was approved by the AJA University of Medical Sciences Ethical Committee and administrative approval was granted for conducting the study at the university. Verbal consent was obtained from participants after providing adequate information about the significance and aim of the study.

Competing interests

The author declares no conflict of interest.

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