ORIGINAL ARTICLE

Examining the Effectiveness of Instructional Multimedia Based on Reducing the Extraneous Cognitive Load in English Language Learning among Nursing Students

Vahid Salehi[1,*], Dariush Noroozi[1], Mohammad Hassan Amirteimoori[1], Ali Delavar[1]

[1]Faculty of Psychology and Educational Sciences, Allameh Tabataba'i University, Tehran, IRAN

[*]Faculty of Psychology and Educational Sciences Allameh Tabataba'i University Tehran, IRAN

Tel: +989380995808
Email: salehi.vahid@yahoo.com

Received: May 23, 2016
Accepted: September 1, 2016

Background: Considering the assumptions of cognitive load theory and using its reduction and optimization strategies in the design and development of instructional content is one of the main requirements for achieving effective learning. This study examined the effectiveness of instructional multimedia based on reducing the extraneous cognitive load in English language learning among nursing students.

Methods: In this study, pretest-posttest design with control group was used. The population included all the undergraduate students of Nursing at Alborz University of Medical Sciences in the academic year 2015-2016. Of these, 36 students were selected through a convenience sampling procedure and were randomly assigned to either of two groups in the study: control ($n=17$) and experimental ($n=19$). The instruments included instructional multimedia lessons and English grammar tests (pretest and posttest). For data analyses, an analysis of covariance (ANCOVA) was applied.

Results: The results showed that the experimental group outperformed the control group on the posttest. This indicated that the instructional multimedia designed based on the reduction of extraneous cognitive load enhanced the learning rate of experimental group when compared to that of the control group.

Conclusions: Using instructional multimedia based on the reduction of extraneous cognitive load helps improve learning by lowering the extraneous cognitive load learners experience during the process of learning.

Keywords: Instructional Multimedia, Extraneous Cognitive Load, English Learning.

بررسی اثربخشی چند رسانه‌ای آموزشی مبتنی بر کاهش بار شناختی بیرونی در یادگیری زبان انگلیسی دانشجویان پرستاری

زمینه و هدف: توجه به بار شناختی و بکارگیری راهبردهای کاهش و بهینه سازی آن در طراحی محتوای آموزشی از ملزومات دستیابی به یادگیری اثربخش است. هدف پژوهش حاضر بررسی اثربخشی چند رسانه‌ای آموزشی مبتنی بر کاهش بار شناختی بیرونی در یادگیری زبان انگلیسی دانشجویان پرستاری بود.

روش: در این پژوهش از طرح پیش‌آزمون-پس‌آزمون با گروه کنترل استفاده شد. جامعه آماری پژوهش را کلیه دانشجویان پرستاری دانشگاه علوم پزشکی البرز در سال تحصیلی ۱۳۹۴-۹۵ تشکیل می‌دادند. از این تعداد، ۳۶ نفر به شیوه نمونه‌گیری در دسترس انتخاب و به صورت تصادفی در دو گروه کنترل (۱۷نفر) و آزمایش (۱۹نفر) گماشته شدند. ابزار مورد استفاده شامل چند رسانه‌ای آموزشی و آزمون های دستور زبان انگلیسی (پیش‌آزمون و پس‌آزمون) بود. برای تحلیل داده‌ها از آزمون آماری کوواریانس (آنکوا) استفاده شد.

یافته ها: یافته‌های پژوهش نشان داد که گروه آزمایش در پس آزمون عملکرد بهتری نسبت به گروه کنترل داشتند. بدین معنا که چند رسانه‌ای طراحی شده مبتنی بر کاهش بار شناختی بیرونی موجب افزایش یادگیری آزمودنی های گروه آزمایش نسبت به گروه کنترل شده بود.

نتیجه گیری: بکارگیری چند رسانه‌ای آموزشی مبتنی بر کاهش بار شناختی بیرونی، با پایین آوردن سطح بار شناختی بیرونی تجربه شده توسط آزمودنی‌ها، موجب افزایش میزان یادگیری آنها می‌گردد.

واژه های کلیدی: چند رسانه‌ای آموزشی، بار شناختی بیرونی، یادگیری انگلیسی.

دراسة مستوى تأثير الاساليب التعليميه المبتنيه على تقليل الحجم المعرفى الخارجى على تعلم اللغة الانجليزيه عند طلاب التمريض

التمهيد و الهدف: إن امعان النظر فى الثقل المعرفى و استخدام أساليب تقليل و تقنين ذالك فى مجال تنظيم المحتوا التعليمى من ملزومات الحصول على تعليم موثر. إن الهدف من هذه الدراسه هو دراسه مستوى تأثير اساليب التعليميه المبتنيه على تقليل الثقل المعرفى الخارجى فى مجال تعلم اللغه الانجيليزيه عند طلاب التمريض.

الأسلوب: تم استخدام أسلوب الاختبار السابق و اللاحق فى هذه الدراسه. و المجموعه الإحصائيه للدراسه عباره عن جميع طلاب كليه التمريض فى جامعه البرز للعلوم الطبيه فى عام ٩٥-٩٤. تم اختيار ٣٦ طالب من هذه المجموعه بشكل عشوايى و تم تقسيمهم الى مجموعتين الاولى فريق الشاهد و هى عباره عن (١٧ طالب) والمجموعه الثانيه فريق الاختبار و هى عباره عن (١٩ طالب) و الوسائل المستخدمه عباره عن الاجهزه التعليميه واختبارات اللغه (الاختبارالسابق و اللاحق) و تم استخدام اختبار كوواريانس (انكوا) لتحليل المعلومات من جهه احصائيه.

النتائج: اشارت النتائج الى أن هناك اداء افضل من قبل فريق الاختبار فى الاختبار اللاحق الشاهد و هذا يعنى الاساليب المتعدده المطروحه و المصممه لتقليل الحجم المعرفى الخارجى له تأثير فى رفع مستوى التعلم فى اختبارات فريق الاختبار بالنسبة الى فريق الشاهد.

الاستنتاج: استخدام هذه الاساليب التعليميه المبتنيه على تقليل الثقل المعرفى الخارجى بناء على تقليل مستوى التقليل المعرفى الخارجى المجرب من قبل الختبارات يؤثر فى رفع مستوى التعلم.

كلمات المفتاح: الاساليب التعليميه، الثقل المعرفى الخارجى، تعلم الإنجليزيه.

نرسنگ طلباء کے لئے تعلیمی بار کم کرنے کی غرض سے ملٹی میڈیا سے انگریزی سیکھنے کے پروگرام کا جائزہ

بیک گراونڈ: تعلیم روشوں کو ہلکا بنانے اور طلباء پر بار کم کرنا تعلیمی حلقوں میں کافی اہمیت کا حامل ہے اور موثر تعلیم کے لئے اسکی ضرورت ہے۔ اس تحقیق کا ھدف یہ دیکھنا ہے کہ اس غرض سے تیار کئے گئے ملٹی میڈیا سے انگریزی سیکھنے میں کتنی موثر مدد مل سکتی ہے۔

روش: اس تحقیق میں پری ٹسٹ اور پوسٹ ٹسٹ کی روش سے استفادہ کیا گیا۔ اس تحقیق میں البرز یونیورسٹی کے تمام طلباء نے شرکت کی ان کا تعلق دوہزار پندرہ اور سولہ کے تعلیمی سال سے ہے۔ ان میں سےچھتیس افراد کا انتخاب کیا گیا اور رینڈم طریقے سے انہیں دو گروہوں میں تقسیم کیا گیا ایک گروہ سترہ افراد کا تھا اور ایک گروہ انیس افراد کا تھا ان لوگوں کو تعلیمی ملٹی میڈیا اور انگلس گرامر کے چند سوالات دئے گئے تھے۔ ڈیٹا کا تجزیہ شماریات کے ٹسٹ کوواریانس آنکو سے کیا گیا۔

نتیجے: اس تحقیق سے پتہ چلتا ہے کہ دوسرے گروہ نے پوسٹ ٹسٹ میں پہلے گروہ سے بہتر کارکردگي کا مظاہرہ کیا ہے کیونکہ ملٹی جو کہ طلباء کا تعلیمی بار کم کرنے کے ھدف سے ڈیزائن کیا گیا تھا اس سے ان نے ان کی تعلیمی صلاحیتوں کو بڑھا وا دینے میں مدد کی۔

سفارش: جیسا کہ دیکھا گیا ملٹی میڈیا جس سے طلباء پر تعلیمی بار کم ہوتا ہو مفید واقع ہوتا ہے لھذا اس روش سے استفادہ کرنا چاہیے۔

کلیدی الفاظ : ملٹی میڈیا، تعلیمی بار، انگریزی ۔

INTRODUCTION

Creating favorable conditions and providing opportunities for achieving a deeper and more lasting level of learning is one of the main goals and ideals of instructional technology. Taking advantage of scientific and instructional techniques, tools and media, technologists and instructional designers seek to design and present the instructional content in a way that is more attractive and easier to understand for learners. Despite this, many technology-based instructions and instructional designs are not of enough effectiveness and efficiency. These types of instructions, rather than facilitating and accelerating learning for the learner, especially for his working memory as a learning bottleneck, induce load or cognitive density, thus slowing and even impeding the process of learning (1). A number of researchers and educational specialists believe that the difficulty of learning a subject arises from its cognitive load (2). The term cognitive load refers to the amount of load on short-term or working memory when processing data to encode that information to accommodate to the long-term memory. This mental effort for processing information is called cognitive load (3). The basic premise of cognitive load theory is that learners, when faced with new information, have a very limited working memory capacity for processing. According to this theory, if the mental burden of instructional content goes beyond the limited capacity of working memory, learning will be disrupted. If the number of elements to be processed simultaneously in the working memory is very high, too high memory capacity is required, and this leads to cognitive overload (4).

Cognitive load theory poses three kinds of cognitive load including intrinsic, extraneous, and germane cognitive loads. Intrinsic cognitive load is determined by the interaction between the nature of the learning material and the learner's level of expertise. Intrinsic cognitive load depends on the number of elements that should be processed simultaneously in working memory. Extraneous cognitive load is related to the processes that not only are not essential but also disrupt learning, and they should be changed through a series of educational interventions. The cause of extraneous cognitive load in multimedia material is providing poor problem-solving techniques, providing information resources that are distracting, unnecessary information-seeking tasks to perform and so on. Germane load, which is caused by cognitive activities that contribute to learning, has been introduced into the theory at a later stage to account for the learning-relevant demands on working memory (3).

Numerous researches have been done in the field of cognitive load theory related to the design of instructional content. A series of studies conducted by Mayer and his colleagues were related to the split-attention effect. It was found that instructions consisting of separate text and unlabelled diagrams were less effective than diagrams that contained labels that clearly connected text and diagram (5, 6). Van Merrienboer and de Croock also conducted a similar study with computer programming content. A generation (conventional) group was compared with a completion group in learning programming techniques. Results indicated superior learning by the completion group. When using a completion strategy, the presentation of new information and programming practice was linked to incomplete programs, and learners were only required to complete the partial solutions, whereas the generation strategy presented both model programs and generation assignments (7). Mayer et al. found that instructional multimedia designed according to multimedia principles lead to more learning compared to conventional methods (8). Kalyuga, Chandler, and Sweller used computer-based instructions in mechanical engineering to compare three different forms of textual explanations presented together with an animated diagram: written text, spoken text and written plus spoken text. The results demonstrated a multimedia redundancy effect. The spoken text group outperformed the written text plus spoken text group with a higher posttest score, a lower number of re-attempts at interactive exercises and a lower subjective rating of cognitive load. Subjective ratings of cognitive load indicated that presenting on-screen textual explanations of the diagram together with the same auditory explanations actually resulted in additional cognitive load (9). In Khalil et al.'s study, which was conducted within the framework of cognitive load theory with interactive anatomical images to achieve the instructional objectives, the researchers showed that with the increasing complexity of instructional materials, images imposed more cognitive load and mental effort, hence reducing learning (10). Paying attention to the human cognitive architecture and taking advantage of the principles of cognitive load theory, Kahol, Vankipuram, and Smith developed a simulator for laparoscopic surgery. Results showed that the experimental group outperformed the control group after eight instructional sessions (11). Mayer and colleagues (as cited in Sweller et al.) demonstrated that representations based on dual channels lowered the information load from the visual channel, reduced extraneous cognitive load, and thus, left more resources for germane cognitive processing (12). Mahbubi et al. showed that the observance of 14 principles of instructional design had a significant effect on reducing cognitive load in the experimental group compared to the control group and also reduced the extraneous cognitive load (13). Mosaramezani, Kanani, and Velayati found that reducing extraneous load and managing intrinsic cognitive load at the same time could increase students' learning. In addition, managing intrinsic cognitive load and reducing extraneous cognitive load simultaneously increases students' retention (14). Kyun, Kalyuga and Sweller showed the effect of reducing extraneous cognitive load on learning of English literature. Students with less knowledge in the worked-example group showed a better performance in problems in the learning stage, although significant effects were not observed in transfer tests, the worked-example group had a better performance compared to traditional problem solving group in the retention test (15). Nückles et al. showed that by increasing learners' skills in journalism, external guidance would be an additional element, thus imposing the extraneous cognitive load. Accordingly, the gradual elimination of instructional guidance with increasing levels of expertise is effective in reducing the negative effects of negative support (16). Qiao et al. found that in sciences such as anatomy and pathology more attention should be paid to the extraneous cognitive load caused by false instructional design. They argued that overlooking this type of load in instructional content poses challenges that might hinder students' learning (17). They also pointed out that cognitive load theory's principles and procedures can be a useful framework for understanding the challenges and success related to the education of medical specialists. Zare, Salari and Sarikhani found that the use of cognitive load theory's instructional strategies could reduce extraneous cognitive load and enhance learning in physiology courses (18). A review of the studies in the field of education and cognitive load shows that using cognitive load theory's effects and strategies in the teaching-learning process can lead to more efficient instructional materials and, accordingly, effective learning outcomes. The aim of this study was to examine the effectiveness of instructional multimedia based on reducing the extraneous cognitive load in English language learning among Nursing students.

METHODS

The present study was quasi-experimental in nature and pretest-posttest with control group in design. The population involved all the undergraduate students of Nursing at Alborz University of Medical Sciences during the academic year 2015-2016. The students taking part in the study were selected based on a convenience sampling procedure and were, then, randomly assigned to either control (n = 17) or experimental group (n = 19). The inclusion criterion was the students' consent to participation in the study.

Two instruments were employed in the study: instructional multimedia lessons and an English grammar test. The instructional multimedia lessons included two separate lessons designed and developed for the two groups in the study. One of the lessons was expected to induce high extraneous load due to the presence of the isolated elements effect (for the control group), and the other inducing low extraneous load due to the elimination of the isolated elements effect (for the experimental group). In terms of contents, the lessons were identical and consisted of English grammar instructional points.

The English grammar test included a 20-item multiple-choice test measuring the grammar points delivered via the instructional multimedia lessons. The test was used as both pretest and posttest; the order of the items across the two administrations was changed in order to minimize practice effect. Each correct item was given one point, adding up to the maximum score of 20. In terms of content validity, two English language experts checked the items, and necessary modifications were made. The test was also piloted among 15 students who did not take part in the study but were from the same population as that of the final sample. Based on the results, the Cronbach's alpha index, as the measure of internal consistency, was 0.79, suggesting the reliability of the test as a whole.

One week prior to study proper, all the participants took the pretest. The study involved two treatment sessions, each lasting about two hours. During the sessions, the experimental group received the instructional multimedia lesson in which the isolated elements effect had been eliminated in order to reduce the extraneous cognitive load. The control group, in contrast, received the lesson with the isolated elements effect expected to induce a high level of extraneous cognitive load. At the end of the second session, the participants in both groups did the posttest. For analyzing the data, descriptive statistics followed by a one-way analysis of covariance (ANCOVA) were applied. All the analyses were completed using SPSS (version 20).

RESULTS

Table 1 shows the descriptive statistics related to the participants' scores on the English grammar test for both pretest and posttest.

As the table shows, the participants' mean scores on the pretest for the two groups were close to one another before the treatment sessions. Nevertheless, the mean scores for both groups increased after the participants received their lessons with the mean score for the experimental group being higher than that of the other group. To investigate whether this difference on the posttest scores was statistically significant, an ANCOVA was conducted. The independent variable included group membership with two levels (viz., control and experimental), and the dependent variable was the scores on the posttest. The participants' scores on the pretest were also added as the covariate to balance out their pre-existing differences in terms of the knowledge of the English grammar points delivered via the instructional multimedia lessons. Table 2 displays the results of the analysis. As viewed in the table, the participants in the experimental group ($M = 13.53$, $SD = 2.09$) significantly outperformed their counterparts in the control group ($M = 9.94$, $SD = 2.22$) on the posttest, $F(1, 33) = 24.12$, $p = .000$, partial eta-squared $= .42$. The effect size, which is large according to Cohen's guidelines (19), showed that 42% of the variation in the posttest scores could be explained by group membership. On the whole, the results suggested that the instructional multimedia lesson designed based on minimizing the level of extraneous cognitive load had a positive effect on the learning of English grammar points among students of Nursing.

Table 1. Descriptive Statistics of Pretest and Posttest Scores across Groups in the Study (N = 36)

Measure	Control group (n = 19)		Experimental group (n = 17)	
	M	SD	M	SD
Pretest	3.47	2.81	3.63	2.69
Posttest	9.94	2.22	13.53	2.09

Table 2. ANCOVA for Posttest Scores across Groups in the Study (N = 36)

Source	Sum of squares	*df*	Mean squares	*F*	*p*	Effect Size[a]
Pretest	0.01	1	0.01	0.00	.951	.00
Group	115.25	1	115.25	24.12	.000*	.42
Error	157.68	33	4.78	--	--	--

* p< .0001.
[a] Partial eta-squared.

DISCUSSION

The aim of this study was to examine the effectiveness of instructional multimedia based on reducing the extraneous cognitive load in English language learning among Nursing students. The results showed that using instructional multimedia designed to reduce the extraneous cognitive load tends to improve students' English language learning. This finding is consistent with results obtained in Khalil et al.'s study showing a decline in learning by increasing cognitive load caused by the complexity of instructional materials (10), Qiao et al.'s study reporting that due to high intrinsic cognitive load in courses such as anatomy, attempt should be made to reduce the extraneous cognitive load (17), Kahol et al.'s study indicating the impact of a simulator on improving scores based on the theory of cognitive load (11), Mosaramezani et al.'s study suggesting that reducing the extraneous cognitive load and managing intrinsic load at the same time could enhance students' learning (14), and Zare et al.'s study supporting that using cognitive load theory strategies could help reduce the extraneous cognitive load and enhance learning in the physiology courses (18). According to the findings, instructional multimedia designed to reduce the extraneous cognitive load enhanced English language learning among Nursing students. This means that by reducing the extraneous cognitive load imposed on learners, their learning increases. Explanation of results is not unexpected, because no instruction without proper instructional design leads to effective learning. On the other hand, one of the requirements of instructional multimedia design is considering the cognitive load effects and applying them in the teaching-learning process. Cognitive load theory can be used in a wide range of learning environments, particularly instructional multimedia, because it relates the design of instructional materials to processing principles and cognitive load effects, and, as a result, learners' cognitive load is minimized, and their learning is maximized. A limitation of this study includes the small sample size, making it difficult to generalize the results. According to the results of the study, it is suggested that educational specialists and multimedia designers should focus on different types of cognitive load principles and strategies to reduce and optimize cognitive load in instructional content.

REFERENCES

1. Kalyuga S. Rapid cognitive assessment of learners' knowledge structures. Learn Instruction 2006; 16: 1-11.
2. Sweller J. Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. Instruct Sci 2004; 32: 9-31.
3. Amirteimouri MH, Zare M. Cognitive load and instructional multimedia. Tehran: Allameh Tabatabai University press; 2015. [In Persian].
4. Plass J, Moreno R, Brunken R. Cognitive load theory. New York: Cambridge University Press; 2010.
5. Mayer RE. Models for understanding. Rev Educ Res 1989; 59: 43-64.
6. Mayer R, Gallini I. When is an illustration worth ten thousand words? Journal of Educational psychology 1990; 82: 715-726.
7. Van Merrienboer JJG, de Croock M. Strategies for computer-based programming instruction: Program completion vs. program generation. J Educ Comput Res 1992; 8(3): 365-94.
8. Mayer R, Moreno R, Boire M, Vagge S. Maximizing constructivist learning from multimedia communications by minimizing cognitive load. J Educ Psychol 1999; 91(4): 38-643.
9. Kalyuga S, Chandler P, Sweller J. Managing split-attention and redundancy inmultimedia instruction. Appl Cogn Psychol 1999; 13: 351-71.
10. Khalil MK, Paas F, Johnson TE, Su YK, Payer AF. Effects of instructional strategies using cross-sections on the recognition of anatomical structures in correlated CT and MR images. Anat Sci Educ 2008; 1: 75-83.
11. Kahol K, Vankipuram M, Smith L. Cognitive simulators for medical education and training. J Biomed Inform 2009; 42: 593-604.
12. Sweller J, Ayres P, Kalyuga S. Cognitive load theory. New York: Hershey; 2011.
13. Mahbubi T, Zare H, Sarmadi MR, Fardanesh H, Feyzi A. Effect principles of instructional design on cognitive load topics learning in multimedia learning environments. Journal of higher education curriculum studies 2012; 3 (6): 29-46. [In Persian]
14. Mosaramezani S, Kanani E, Velayati E. Investigation effect control the load imposed on the storage and retention of learning English grammar. New thoughts on education 2013; 9(1): 105-32. [In Persian].
15. Kyun S, Kalyuga S, Sweller J. The effect of worked examples when learning to write essays in English literature. J Exper Educ 2013; 81(3): 385-408.
16. Nückles M, Hübner S, Dümer S, Renkl A. Expertise reversal effects in writing to learn. Instruct Sci 2014; 38: 237-58.
17. Qiao YQ, Shen J, Liang X, Ding S, Chen FY, Shao L, Zheng Q. Using cognitive theory to facilitate medical education. BMC Med Educ 2014; 14(79): 1-7.
18. Zare M, Salari M, Sarikhani R. The impact of educational strategies of cognitive load theory on extraneous cognitive load and learning in physiology course. J Med Edu Dev 2016; 9(22): 44-52.
19. Cohen J. Statistical power analysis for the behavioral sciences. Newbury Park: CA: Sage; 1988.