Website: http: jebhpme.ssu.ac.ir
EBHPME 2025; 9(2): 78-86
EISSN: 2538-4716

Evidence Based Health Policy, Management & Economics

ORIGINAL ARTICLE

The Effect of Mobile-Based Learning on Cognitive Load and Learning in Environmental Health Education

Kamaleddin Khorrami[1, 2], Fatemeh Keshmiri[3], Sara Jambarsang[4], Mehdi Mokhtari[1], Fahimeh Teimouri[1*]

[1] Environmental Sciences and Technology Research Center, Department of Environmental Health Engineering, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[2] Student Research committee, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[3] Medical Education Department, Educational Development Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[4] Center for Healthcare Data Modeling, Departments of Biostatistics and Epidemiology, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

ABSTRACT

Background: The growth of educational technologies has led to the development of mobile-based education. The purpose of this investigation was to examine the influence of mobile-based learning (M-learning) on the cognitive load, learning, and satisfaction of students in environmental health Engineering (EHE).

Methods: The quasi-experimental study was carried out in X University of Medical Sciences. Students of EHE (n=30) participated in the intervention and control groups. In the intervention group, students were trained to use the mobile-based learning method(M-learning). Students in the control group participated in the traditional training. The students' satisfaction and cognitive load were assessed using questionnaires. Students' learning was assessed by multiple-choice questions with multiple answers. The data were analyzed using $SPSS_{24}$ software.

Results: The results showed that students in the intervention group demonstrated 8.53±1.06 as learning scores, significantly higher than those of the control group (4.18±1.57). The intrinsic and extraneous cognitive load of the intervention group was significantly lower (*P-values*<0.001). The germane cognitive load was significantly higher in intervention students (*P-values*<0.001). Also, the results of the students' satisfaction questionnaire showed that the participants were highly satisfied with the educational content, efficiency, and ease of use of the application (8.03±0.27), which was reported at a good level (level 6-8 out of 9).

Conclusion: The M-learning method is recommended as an effective tool for teaching the conventional activated sludge process to undergraduate environmental health engineering students. This method effectively creates a germane cognitive load by using game elements and facilitated learning at any time and any place.

Keywords: Mobile-based learning, Environmental health, Application, Cognitive load

Introduction

Mobile-based learning (M-learning) has been introduced as one of the common tools for digital education (1). This method enables students to capitalize on every learning opportunity. In M-learning, It employs diverse resources, including prepared content, video recordings, and digital applications (2). Chase et al. (3) demonstrated that M-learning is an effective teaching tool for diverse situations in the process of traditional, formal, and informal education in the workplace-based

Corresponding Author: Fahimeh Teimouri
Email: f.teimouri1401@gmail.com
Tel: +98 31492151
Environmental Sciences and Technology Research Center, Department of Environmental Health Engineering, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

[DOI: 10.18502/jebhpme.v9i2.20201]

learning and classroom. By transforming experience into effective educational opportunities, this method has catalyzed the widespread integration of mobile learning within medical science curricula. Also, this method allows students to review their notes and learnings in between practical activities and compare them with the real environment. They can complete or modify their learning (3). The use of mobile applications has been recommended as a valid and effective method in M-learning (2). These tools can provide a good opportunity to learn and share health information (2, 4, 5).

A key factor in the effectiveness of M-learning is cognitive load. The cognitive load refers to the amount of required effort to perform mental processes. Every mental task, from memory to perception to language, creates cognitive load because it requires energy and effort. When a cognitive load is high, mental processes are disrupted (6). M-learning requires minimizing the mental effort of users when designing user interface elements. Cognitive load theory identifies three primary types of cognitive load; intrinsic cognitive, external, and desirable cognitive load have an effective role in learning. Intrinsic cognitive load (ICL) refers to the complexity or automatic intrinsic cognitive difficulty (task) and is determined based on the nature of the content. Some tasks, such as solving complex math problems or understanding complex scientific concepts, naturally require more mental effort and cognitive resources. The intrinsic cognitive load of each task is influenced by factors such as the complexity of the content, the number of interactive elements, and the need to coordinate several cognitive processes at the same time. Extraneous cognitive load (ECL) refers to the cognitive load that is imposed on a person by external factors that are not directly related to the work content. ECL comes from the way the task is presented or designed. Examples of ECL factors include presentation, organization of information, presence of distractions, and clarity of instructions. Germane cognitive load (GCL) refers to cognitive effort in activities that directly contribute to learning and building long-term memory, which include activities such as creating the connection between new and existing knowledge, analyzing and synthesizing information, and applying problem-solving strategies (6).

While the use of E-learning tools has become widespread in many fields, its application is needed for expansion in EHE (Environmental Health Education) courses (7). By using these tools, education can be made more attractive, more effective, and can provide an effective learning opportunity. One of the important topics in environmental health is the course of environmental microbiology. Some of the course outlines need to understand the interactions of microorganisms in the wastewater treatment processes. A key problem related to wastewater microbiology education is related to un-availability of advanced features, completed wastewater treatment plants, and not enough knowledge about the contents. In this study, M-learning refers to an interactive, smartphone-based educational approach designed to facilitate flexible and accessible learning. The mobile learning simulation involved digital content delivery through a dedicated application, allowing students to access lessons, quizzes, and multimedia materials. The app likely incorporated gamification elements such as quizzes, progress tracking, and rewards to enhance engagement and optimize cognitive load. Unlike traditional lectures, the M-learning method enabled self-paced study, giving students the flexibility to learn anytime and anywhere. Interactive assessments, including multiple-choice questions, were embedded in the app to evaluate knowledge retention. The primary objective of this study was to evaluate the impact of M-learning on cognitive load, learning outcomes, and student satisfaction among (EHE) students. Specifically, the study aimed to compare the effectiveness of M-learning versus traditional classroom instruction in enhancing students' understanding of the conventional activated sludge process.

[DOI: 10.18502/jebhpme.v9i2.20201]

Materials and Methods

This quasi-experimental investigation was carried out during the 2023-2024 academic year at X University of Medical Sciences. This design is suitable for evaluating the impact of an intervention in situations where randomization is not feasible or practical, particularly in educational settings. The design allows for the evaluation of educational interventions in real environments, even though there are some concerns (8).

- *participate and study setting*

The studied populations were undergraduate students of EHE. The sample size was calculated by considering the confidence level of 95% and the power of 80, referring to the initial values of Tabandeh et al.'s study (9). Thirty undergraduate students of environmental health engineering (15 among participants who received the intervention and 15 a contrast to the control condition) participated in this study.

$$n_1 = n_2 = \frac{(S_1{}^2 + S_2{}^2)(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2}{(\bar{X}_1 - \bar{X}_2)^2}$$
$$= \frac{(2.3^2 + 1.6^2) \times (1.96 + 0.84)^2}{(16-14)^2} = 15$$

Due to the limited population size, the sample size was calculated using a formula to achieve the assumed effect size. Therefore, the obtained results are reliable and can be attributed to the magnitude of the effect presented in the text.

- *Educational program*

The educational program was developed according to the literature and expert opening in the first step. The databases of Web of Science, Scopus, PubMed with the keywords Environmental Microbiology software, microbiology of wastewater treatment, and electronic training, conventional activated sludge wastewater treatment application in the period of 2015-2022 were reviewed. The literature was reviewed in English and Persian. The findings of the review were discussed in the expert panel sessions where 5 members of the Faculty of Environmental Health and Medical Education and 2 of the graduates participated. In the panel, educational goals, process and conceptual content, organization of information, and educational techniques for designing the program according to the principles of M-learning were discussed. The objective of the training program was to understand the common processes of biological wastewater treatment and their exploitation problems (conventional activated sludge).

Game elements were also considered, which included points, badges, leaderboards, feedback, and challenging scenarios related to active sludge, and a concept map was used to train the sludge process and concept. The validity of the mobile-based educational program was assessed from the viewpoints of 5 members of the EHE faculty in the expert panel. The suggestions were reviewed, and the M-learning application was finalized in the expert panel.

The M-learning application included the following sections; teaching concepts using conceptual maps (diagram models and spider and process maps), conventional activated sludge treatment processes in three sections; treatment process, proper operation, and improper operation (bulking sludge, rising sludge, dispersed growth, and pinpoint floc) using animation and images; and self-evaluation (extended matching, multiple choice questions, and scenario-based questions).

M-learning in intervention group:

In the intervention group, students participated in briefing sessions. Students then explored the application's interface in small groups, familiarizing themselves with its various panels through guided practice. They could work with the application environment and were taught how to work. The students in the experimental group were trained by the M-learning application for one month. Moreover, the students asked their questions in the forum. The activity of the participants was assessed in the management panel of the M-learning application. The students finally received feedback about their learning in the M-learning.

Traditional method in the control group:

[DOI: 10.18502/jebhpme.v9i2.20201]

The students in the control group also participated in the traditional training sessions that were conducted using the lecture method (3 sessions). The topics were similar in both groups and the difference was in the teaching method.

After one month, the satisfaction, learning, and perception of the cognitive load of the students were assessed.

- *Study tools*

QUIS questionnaire (Questionnaire for user interface satisfaction) was used to assess the M-learning educational implementation capability. This questionnaire was compiled by Snoswell in 2016 (10) and included 27 questions related to the evaluation of usability in 5 domains, including working with the software (6 items), screen (4 items), terminology and software information (6 items), the learning ability of the software (6 items) and the general capabilities of the software (5 items). Each question has an answer with a score of 0-9, where zero indicates the lowest level and 9 indicates the highest level of satisfaction. A score of 0-2 was classified as poor, 3-5 as moderate, and 6-8 as good, and 9 as excellent. The questionnaire was found to be both valid and reliable in Faradmal's study (α = 0.94) (11).

The cognitive load of the participants was assessed by a cognitive load questionnaire by Krieglstein et al. (2022) (12). This questionnaire has 15 items in three domains of ICL (5 items), ECL (5 items), and GCL (5 items). Each item scored in the range 1-9, where 1 indicates the lowest and 9 indicates the highest cognitive load. This questionnaire was validated by Keshmiri et al. (Cronbach's alpha 0.86) (13).

The learning of the participants in both groups was evaluated with multiple-choice questions with multiple correct answers. The types of questions can be used to assess deeper understanding, requiring students to analyze and synthesize information to identify multiple correct answers. The questions were validated and confirmed using the opinions of environmental health experts.

- *Data analysis*

Data was analyzed using descriptive (percentage, mean, SD) and inferential (ANCOVA, pair t-test) indicators by version 26 of SPSS software.

Results

The demographic data for all participants are provided in Table 1.

Table 1. Socio- demographic characterization

Variable	Group	Mean	SD	*P*
Age	Intervention	21.60	1.24	<0.001
	Control	20.00	0.65	
GPA*	Intervention	16.33	0.68	0.76
	Control	16.23	1.10	

*Grade point average

It should be noted that all students in both the control and intervention groups were female. Table 2 shows the results of the statistical analysis of the variables of the cognitive load questionnaire as well as the covariance used to compare the learning and cognitive load scores after adjusting the age variable.

Table 2. The cognitive load types of the students in the experimental and control conditions

Variable	Intervention		Control		P	Effect size
	Mean	SD	Mean	SD		
ICL*	1.14	0.23	5.70	2.11	<0.001	0.468
ECL**	1.45	0.31	5.02	1.86	<0.001	0.417
GCL***	7.90	0.54	5.44	1.62	<0.001	0.653

*Intrinsic Cognitive Load (ICL)
**Extraneous Cognitive Load (ECL)
*** Germane Cognitive Load (GCL)

[DOI: 10.18502/jebhpme.v9i2.20201]

The mean (standard deviation) of ECL is 1.45±0.31 and 5.02±1.86 for the experimental and control groups, respectively. The t-test finding showed that the ECL was significantly lower in the intervention group (*P-values*<0.001), and the intervention group had a more constructive interaction. The intervention group had a lower extraneous cognitive load and a better test score. The mean (standard deviation) of GCL in the intervention and control groups was 7.90±0.54 and 5.44±1.62, respectively. The results of the study showed that the GCL was significantly higher in the intervention group. Furthermore, the GCL is significantly higher in the intervention group (*P-values* <0.05) According to the covariance test, there was a significant relationship between the GCL and the score obtained from the test by adjusting the age of the students. Thus, the intervention group got a higher cognitive load and a better test score. Table 3 shows the descriptive and analytical comparison of test scores in two groups.

Table 4 presents the students' satisfaction scores regarding the e-learning approach.

Table 3. The learning scores of students in the intervention and control groups

Variable	Group	Mean	SD	*P*
Test score	Intervention	8.53	1.06	<0.001
	Control	4.18	1.57	

Table 4. M-learning students' satisfaction

Variable	Mean	SD
Application using	6.93	0.51
Screen page	8.60	0.37
Application information package	8.38	0.35
Learn application capability	8.27	0.55
Total application capabilities	8.20	0.43

As presented in Table 4, the mean and standard deviation of satisfaction questionnaire variables—including working with the software, display interface, software modification and information set, software learnability, overall software capabilities, and general satisfaction—were 6.93±0.51, 8.60±0.37, 8.38±0.35, 8.27±0.55, 8.20±0.43, and 8.03±0.27, respectively. Given that all the six means fell within the score range of 6 to 8 (on a 9-point scale), it can be concluded that users' overall satisfaction with the Micro-Cave application was at a good level (6-8 out of 9).

Discussion

The results indicated a significant relationship between the test scores of the two groups. The test scores were higher in the intervention group than the control group.

This mobile learning application employs a concept-based framework enhanced by gamification, thereby enabling students to exercise greater autonomy over their personalized learning trajectories. The study revealed that M-learning positively and significantly influenced students' academic achievement and their level of satisfaction. In addition, the M-learning improved the GCL and decreased the ICL and ECL.

Wastewater microbiology is known as an important field of environmental health, and its understanding needs repetition and practice stated in the present study. The results showed that the students who used M-learning achieved higher scores than the students in the control group. In the M-learning concept map was used to understand the conventional activated sludge process. Completing concept maps has created an orderly and coherent pattern for learning microbiology concepts. Also, the self-evaluation panel, by creating various scenario-based opportunities, exposed the students to simulated conditions in the treatment plant and increased the learning opportunities among the participants. In addition, due to the extensive and staged content in the activated sludge treatment process, the use of adaptive tests has provided a suitable learning opportunity for classified and processed subjects. Instant feedback as well as the opportunity to complete examinations multiple times could have a positive effect on students' learning. In the environmental microbiology course, microbial agents have interactions that are not visible and reduce student understanding of traditional

[DOI: 10.18502/jebhpme.v9i2.20201]

learning methods. The use of an M-learning application allows students to be depicted in interactions. Students will be provided with the opportunity to better understand and learn from the process by using animations and movement between elements in each part of the activated sludge treatment process. Mokmin et al (14) showed that the use of technology in education creates effective learning and motivation for learning without increasing extraneous cognitive load.

The students' satisfaction was reported at a favorable level. Game components have been effective in creating excitement and competition and have increased the satisfaction of students. The E-learning method had an impact on the better understanding of concepts, learning, and satisfaction of students. The conducted study by Shatha Mohammed Almalki and Imam Abdulrahman (2024) showed that M-learning facilitated interactions and strengthened their cooperation which led to students enjoying the learning. In addition, teaching via the M-learning method encourages students to evaluate their ideas before presenting them. This method helped the students to understand and remember the content of the relevant course (15).

The students' satisfaction may be achieved due to the user-friendly and simple design of the M-learning. Students easily access and use educational content. Furthermore, the application allows students to access educational content at any time. The spatiotemporal flexibility afforded by the software has resulted in enhanced user satisfaction and made the learning process more attractive and enjoyable by using interactive tools such as animation, simulation, and educational scenarios. These features helped users understand complex concepts better and gain a deeper understanding of the topics. The use of gamification elements increased the motivation of students to learn and increased the competition among students. Chang et al. (2021) showed that using the application in simulated education creates a favorable cognitive load and also improves the learning and satisfaction of students (16). Goma et al, indicated that the use of M-learning for nursing students has motivated self-confidence and satisfaction (17). Moreover, Anshu Miglani and Ashish Kumar (2017) showed that there were positive perceptions toward M-learning among educators. The educators confirmed that mutual learning has the potential to engage the learner, collaboration is carried out to a greater extent, and educational conversation is increased (18).

Cognitive load has been introduced as an important factor in M-learning educational applications. According to the cognitive load theory, three types of ICL, ECL, and GCL affect learning. GCL means trying to build and modify learning schemas, which are largely controlled by job components such as motivation, effort, and comprehensive metacognitive skills. Intrinsic and extraneous cognitive load must be managed and the desired load increased (7, 19). The present study showed that the average scores of intrinsic cognitive loads, extraneous cognitive load, and GCL in the M-learning group had a significant difference compared to the control group. The intervention group had less intrinsic cognitive load, extraneous cognitive load, and more favorable cognitive load than the control group. The results confirm that M-learning created advantage for students to train well and without creating a cognitive load that disrupts education, which includes ICL, and ECL. Strategies of cognitive load theory (20) include sorting content from easy to difficult, presenting solved examples (concept maps of the training panel), completing half-solved matrices or/and half-completed examples (concept map in self-evaluation), solution steps of the problem (appropriate and inappropriate strategic processes in purification), various scenarios/examples (scenario-based questions), asking various questions and providing feedback after solving the problem observed by the students. These principles of cognitive load theory (21) are the key effective factors in creating germane cognitive load and reducing ICL and ECL, which have been observed in the design of the application.

Intrinsic cognitive load refers to the inherent

[DOI: 10.18502/jebhpme.v9i2.20201]

complexity of the educational content. In other words, the more interconnected the elements within a learning material are, the higher the intrinsic cognitive load it imposes on the learners' working memory. In the intervention group, the use of animated concept maps and animations depicting the processes of activated sludge led to a better understanding of the educational material, reducing its perceived complexity and resulting in a lower intrinsic cognitive load compared to the lecture method.

ECL is related to the manner in which the instructional content is presented. A coherent structure—incorporating concept maps, game-like elements, diverse assessments, and immediate feedback—can effectively reduce the extraneous cognitive load. This is in contrast to the lecture method, which often presents information using only audio and visual elements (e.g., a slide deck with narration), a format that can impose a higher extraneous load.

Creating an interactive learning opportunity, providing instant feedback, exposing learners to various challenges during the instruction process, and offering the ability to use educational materials tailored to their needs can all contribute to establishing a desirable GCL in M-learning.

Becker (2020) indicated that one of the problems of students' learning is extraneous cognitive load. The use of mobile technology in the learning process can reduce extraneous cognitive load and optimize students' conceptual learning (22). Nasim Saeed and Akbar Jadidi (2021) showed the positive effect of –M-learning on learning, concentration, and student satisfaction. This means that E-learning can increase the learning, concentration skills, and academic satisfaction of students (23). In the traditional method, the opportunity to learn was available at a certain time, the training classes were mostly one-way, and the students were less involved, which caused fatigue. In the M-learning method, in addition to using the visual dimension of the application, the students have the opportunity to observe detailed interactions and interact with the software in the self-assessment and concept map sections. Therefore, this key finding can contribute to a higher GCL. The current results have been in accordance with the study of Rahbar et al. with the aim of developing E-learning materials based on cognitive load theory to improve learning in online education. In this study, the results of the analysis of covariance for learning levels showed that the design of electronic content based on cognitive load theory led to a greater improvement in learning levels in the experimental group relative to the control group and between the intervention and control groups in terms of their memorization (24).

Limitation

The quasi-experimental design such as randomization restricted the generalizability of the results. Moreover, the limitations of sample size and the short training period were the limitations of the present study.

Conclusion

The use of M-learning method facilitated the learning of complex concepts of microbiological-activated sludge processes in a simple and comprehensible manner due to the use of animations and interactive simulations. This feature improved the satisfaction and learning of the intervention group compared to the control group. In addition, the results showed that the GCL, which facilitates the appropriate educational opportunity, is significantly higher in the learning method based on M-learning than in the traditional method. It is recommended to use an M-learning approach with a focus on gamification components in the teaching of the other practical lessons in this field.

Ethical consideration

This study was approved at Ethics committee of Shahid Sadoughi University of Medical Sciences. (ID: IR.SSU.SPH.REC.1402.027).

Acknowledgments

The authors would like to thank the Shahid Sadoughi University of Medical Sciences for support of the current research (Code number: 14889).

Authors' contributions

This article is based on an M.Sc thesis student prepared by K.Kh. All authors contributed to the study conception. Experimentation and application design were per-formed by F.T, F.K and M.M. Data analysis was conducted by S.J. The draft manuscript was written by K.Kh, F.K and F.T. All authors read and approved the final manuscript.

Conflict of Interests

The authors declared no conflicts of interest.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article. This project is funded by Shahid Sadoughi University of Medical Sciences University of Medical Sciences (ID: 14899).

References

1. Dunleavy G, Nikolaou CK, Nifakos S, Atun R, Law GCY, Tudor Car L. Mobile digital education for health professions: systematic review and meta-analysis by the digital health education collaboration. Journal of medical Internet research. 2019;21(2):e1293.7
2. Qureshi MI, Khan N, Hassan Gillani SMA, Raza H. A systematic review of past decade of mobile learning: What we learned and where to go. International Journal of Interactive Mobile Technologies. 2020;14(6.(
3. Chase TJ, Julius A, Chandan JS, Powell E ,Hall CS, Phillips BL, et al. Mobile learning in medicine: an evaluation of attitudes and behaviours of medical students. BMC medical education. 2018;18(1):1-8.
4. Brown TH, Mbati LS. Mobile learning: Moving past the myths and embracing the opportunities . International Review of Research in Open and Distributed Learning. 2015;16(2):115-35.
5. Fan K-K, Xiao P-w, Su C. The effects of learning styles and meaningful learning on the learning achievement of gamification health education curriculum. Eurasia Journal of Mathematics, Science and Technology Education. 2015;11(5):1211-29.
6. Brunken R, Moreno R, Plass JL. Cognitive load theory: Cambridge University Press; 2010.
7. Agarwal A, Sharma S, Kumar V, Kaur M. Effect of E-learning on public health and environment during COVID-19 lockdown. Big Data Mining and Analytics. 2021;4(2):104-15.
8. Lynch DC, Whitley TW, Willis SEJ. A rationale for using synthetic designs in medical education research. Advances in health sciences education. 2000;5:93-103.
9. Mehrabi M ,Tabandeh Z, Zarshenas L, Nekooeian AA, Sarani EM. The Effects of Mobile Learning and Group Discussion for Psychotropic Drug Education on Nursing Students' Learning, Satisfaction, and Attitude: An Educational Intervention. Shiraz E-Medical Journal. 2024.(2)25;
10. Mehdizadeh H, Fadaizadeh L. Re-designing and evaluation of tele-dermatology software for skin diseases. Journal of Health and Biomedical Informatics. 2018;4(4):279-90.
11. Faradmal J, Keshvari Kamran J. The validity and reliability of an usability assessment tool for a web-based software. Iranian Journal of Ergonomics. 2014;2(3):57-69.
12. Krieglstein F, Beege M, Rey GD, Sanchez-Stockhammer C, Schneider S. Development and validation of a theory-based questionnaire to measure different types of cognitive load. Educational Psychology Review. 2023;35(1):9.
13. Hosseinpour A, Keshmiri F. The effect of interprofessional game-based learning on perceived cognitive load and self-efficacy in interprofessional communication and collaboration in patient safety incidents. J PloS one. 2025;20(4):e0321346.
14. Mokmin NAM, Hanjun S, Jing C, Qi S. Impact of an AR-based learning approach on the learning achievement, motivation, and cognitive load of students on a design course. Journal of Computers in Education. 2024;11(2):557-74.
15. Almalki SM. Exploring Students' Perspectives on the Implementation of a Self-Organised Learning Environment: SOLE via Mobile Devices. International Journal of Mobile and Blended Learning (IJMBL). 2024;16(1):1-19.
16. Chang H-Y, Wu H-F, Chang Y-C, Tseng Y-S, Wang Y-C. The effects of a virtual simulation-based, mobile

[DOI: 10.18502/jebhpme.v9i2.20201]

technology application on nursing students' learning achievement and cognitive load: Randomized controlled trial. International Journal of Nursing Studies. 2021;120:103948.

17. Gomaa EM, Ali ZH, Abd-Elgalil H. Effect of mobile-based learning on second year nursing students' clinical competence and motivation. Nurs Health Sci. 2020;9:27-37.
18. Miglani A, Awadhiya AK. Mobile learning: readiness and perceptions of teachers of Open Universities of Commonwealth Asia. Journal of Learning for Development. 2017;4(1.(
19. Buchner J, Buntins K, Kerres M. The impact of augmented reality on cognitive load and performance: A systematic review. Journal of Computer Assisted Learning. 2022;38(1):285-303.
20. Sawicka A. Dynamics of cognitive load theory: A model-based approach. Computers in human behavior.1041-66:(3)24;2008 .
21. Ghanbari S, Haghani F, Barekatain M, Jamali A. A systematized review of cognitive load theory in health sciences education and a perspective from cognitive neuroscience. Journal of Education and Health Promotion. 2020;9(1):176.
22. Becker S, Klein P, Gößling A, Kuhn J. Using mobile devices to enhance inquiry-based learning processes. Learning and Instruction. 2020;69:101350.
23. Saeid N, Jadidi Mohammadabadi A. The effect of mobile learning on students' learning, concentration and academic satisfaction. Technology of Education Journal (TEJ). 2022;16(3):439-50.
24. Rahbar Z, Ahmadi F, Saidi M. Developing E-learning Materials Based on Cognitive Load Theory to Improve Students' Learning Levels in Online Physics Education. Technology of Education Journal (TEJ). 2024;18(1).

[DOI: 10.18502/jebhpme.v9i2.20201]