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Original Article

Comparing the Effects of Interactive Multimedia and Video-Based Instruction on Students' Cognitive Load and Course Interest: A Semi-Experimental Pilot Study

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ABSTRACT

Background: With the rapid expansion of virtual learning, especially during the COVID-19 pandemic, there is a growing need to evaluate the effectiveness of different virtual teaching methods. This study aimed to compare the effects of interactive multimedia-based and video-based virtual education on cognitive load and course interest among postgraduate students.

Methods: This semi-experimental study was conducted with a pre-test and post-test design among 29 master's students who were taking a research methods course at Arak University, Iran, between September 2021 and June 2022. Participants were assigned to two intervention groups: interactive multimedia (n=16) and video-based education (n=13). Both groups received the same instructional content through their respective virtual formats over a three-month period. Cognitive load was measured using the Paas Cognitive Load Scale (1994), and course interest was assessed with the Keller and Sobia Interest in Course Questionnaire (1993). Data were analyzed using paired t-tests and independent t-tests in SPSS version 26.

Results: Both the interactive multimedia and video-based groups showed a significant decrease in cognitive load from pre-test to post-test (P=0.01 for both), with no significant difference between groups at either time point (pre-test P=0.75, post-test P=0.63). Regarding course interest, both groups showed significant improvement in the attention dimension (P=0.03 for multimedia, P=0.04 for video), but only the interactive multimedia group demonstrated significant increases in relevance, confidence, and satisfaction. There were no significant differences between the groups in any variable at the start or after the intervention.

Conclusion: Educational videos and interactive multimedia seem to ease cognitive load and support learning by activating various sensory channels. Furthermore, these tools allow students to practice, review, and learn at their own pace, which can lead to more profound learning. The interactive features of digital content can also make the learning environment more attractive, thereby boosting student engagement and persistence.

Keywords: Education, Distance, Multimedia, Video-Assisted, Cognitive Load, Course Interest, Audiovisual Aids

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Introduction

Online learning, as an innovative approach to education, has been rapidly growing in recent years, and this has been especially evident during the COVID-19 pandemic. The usage of online educational platforms significantly increased during this period, reaching ten times its previous level. This rapid growth of online learning has demonstrated a revolutionary role in facilitating access to education. This trend not only simplified finding balance in hectic schedules but also allowed people who were unable to attend in-person classes because of location or other constraints to access educational resources worldwide. Online learning successfully minimizes barriers to education while providing customized learning experiences and flexibility for students. These advancements have transformed conventional teaching approaches and opened new possibilities for the future of education and learning (1). Thanks to the Internet's capacity to transcend physical boundaries, online education has rapidly become a widely accepted and sought-after mode of learning (2). The advancement and application of communication technologies within educational systems represent a transformative shift in learning, enabling the delivery and accessibility of educational content over geographical distances (3). Technological progress has introduced innovative opportunities for educators to develop and improve teaching strategies. These technological changes have greatly influenced learning, particularly in the approaches to teaching (4).

Virtual education is a form of online learning recognized as a valid educational approach. In this setting, both the teacher and students join a virtual classroom at a designated time to engage with each other within a digital environment. Educators can present learning materials such as PDF documents, PowerPoint presentations, audio, and video content to students (5). To address the challenge of limited interaction, this virtual environment should be used strategically. Integrating virtual spaces into the education design and lesson planning can enhance opportunities for meaningful interaction (6). The implementation of this new technology necessitates establishing the essential infrastructure, as well as training and creating a suitable environment to support the provision and utilization of multiple facilities and capabilities (7). Additionally, several elements contribute to the success of virtual learning, including the backing of academic staff, the presence of a support system, organizational dedication, effective management, trainer expertise, and the way services and infrastructure are delivered (8). Various factors such as orientation, motivation, necessary resources, and differing circumstances influence the effectiveness of virtual learning. The worldwide enforced shutdowns introduced a new way of life globally, but the impact on the education sector was particularly profound (9).

Cognitive load theory is an educational framework grounded in our understanding of human cognition. It posits that learners have a finite ability to process new information, and if the mental effort required surpasses the capacity of their working memory, learning will be hindered (10). In virtual learning settings, students can advance at their own speed and engage with the material in ways that best suit their individual needs. This self-directed approach helps to alleviate cognitive load and reduce stress. Additionally, online courses deliver the necessary information promptly, allowing students to access course content anytime and from any location (11). Consequently, one of the key characteristics of a successful academic program is its ability to generate interest in the course material. In modern education, engaging learners' interest in their courses is vital, with inspiring enthusiasm for learning recognized as a primary objective in advanced societies (12). Interest in a course is seen as a set of behaviors that promote overall engagement and adaptation when performing specific tasks, leading to greater comfort, well-being, and lower anxiety levels (13).

Virtual education supports this process by offering a wide range of learning resources and flexible timing, which can help manage students' cognitive load (14, 15). Essentially, an interest in learning embodies both curiosity and motivation, serving as a vital force that encourages individuals to take on and persist in academic tasks (14-16).

Despite these benefits, challenges remain concerning the quality and depth of learning in online settings. A key issue is whether virtual education can genuinely promote deep, meaningful engagement and maintain students' sustained interest, especially without in-person interaction and instant feedback. Additionally, managing cognitive load in digital learning environments is a significant issue. Although online platforms offer convenience and accessibility, the vast amount of information and the necessity for self-discipline can occasionally overwhelm learners, which may hinder their academic success (17, 18).

Given the increasing reliance on multimedia tools—such as interactive videos, animations, and simulations—in virtual classrooms, it is essential to assess whether these technologies can mitigate cognitive overload and enhance student engagement more effectively than traditional, teacher-centered approaches.

With the growing dependence on multimedia tools—such as interactive videos, animations, and simulations—in virtual classrooms, it becomes crucial to evaluate whether these technologies can better alleviate cognitive overload and boost student engagement compared to conventional teacher-centered methods. Moreover, incorporating multimedia and interactive content is thought to stimulate multiple sensory pathways, potentially promoting deeper learning, improved retention, and catering to varied learning preferences (19-22). However, empirical findings on how these approaches stack up against one another remain scarce and sometimes inconsistent.

As new technologies continue to emerge in online education, it is important to assess whether multimedia tools simply enhance students' comprehension and interest or if they deliver more substantial benefits over traditional learning strategies. Specifically, can these technologies foster more active and meaningful learning experiences while effectively increasing learners' engagement and reducing cognitive burden relative to teacher-centered instruction?

Therefore, the primary focus of this study is to determine whether virtual learning environments that incorporate interactive multimedia and video can decrease cognitive load and heighten students' enthusiasm for the subject matter, compared to standard instructional techniques. This investigation seeks to guide the development of effective and engaging online education practices in the post-pandemic landscape.

Methods

Study Design and Setting

The study utilized a semi-experimental design incorporating pre-test and post-test evaluations. Carried out from September 2021 to June 2022 at Arak University in Iran, the research commenced after the researcher spent three months designing and developing educational software. Once the supervisors gave their approval and the class was chosen, the group using interactive multimedia and video was formed.

Intervention

Once the groups were formed, participants took pre-tests to assess their interest in the course and cognitive load. The intervention phase then began and lasted for three continuous months. During this period, both groups received training through a Learning Management System (LMS) platform. It is important to highlight that both the interactive multimedia group and the educational video group were provided with identical instructional content on the research methodology course, presented via interactive multimedia. The training was delivered in group sessions, consisting of 16 sessions, each lasting 90 minutes.

Interactive multimedia group: This group received instruction based on the Educational Sciences curriculum for the research methodology course, delivered through PowerPoint presentations that included voice narration and animations created using iSpring software.

Video-based education group: This group attended sessions featuring educational videos produced using the Monta website, a platform designed for creating instructional content. At the end of the semester, students in both groups took post-tests measuring cognitive load and interest in the course, with assessments spaced one week apart. The outcomes from these groups were then analyzed to determine the impact of the different teaching methods.

Participants and Sampling

To conduct the research, a visit was arranged to the Faculty of Educational Sciences, where required approvals were secured from the appropriate authorities with assistance from faculty members. Owing to the limitations imposed by the virtual education period and the small pool of postgraduate students, a convenience sampling approach was employed to select 29 master's students from different specializations within the Educational Sciences program.

The inclusion criteria encompassed all students who attended the Research Methodology course between September 2021 and June 2022 and chose to participate voluntarily in the study. Those who did not complete either the pre-test or post-test phases were excluded. A total of 29 students fulfilled the inclusion criteria; these students were enrolled in two different sections of the same course and took part in the study. To minimize information sharing between students, participants were selected from two separate classes, both taking the identical course. The students were unaware that the other class was also part of the research. Among these 29 participants, 16 were assigned to the interactive multimedia group, while 13 were placed in the video group. The schematic view of research design is illustrated in Figure 1.

Tools/Instruments

In this study, two standard questionnaires were used:

a) Paas cognitive load scale (1994): To measure cognitive load, this study employed the Paas Cognitive Load Scale (1994), a widely used subjective rating tool designed to assess the amount of mental effort participants invest in a learning task. It features a single-item, 9-point Likert scale, where learners rate their perceived mental effort immediately after the task. Ratings range from 1 (very, very low mental effort) to 9 (very, very high mental effort), with participants choosing the number that best represents the extent of their cognitive involvement in the instructional activity. Despite its simplicity, this scale effectively captures the cognitive demands of various teaching methods and has been validated in multiple educational research settings. When combined with performance outcomes, these self-reported mental effort scores enable researchers to assess the efficiency and effectiveness of instructional designs. The questionnaire assesses only one overall component, where higher scores indicate greater cognitive load.

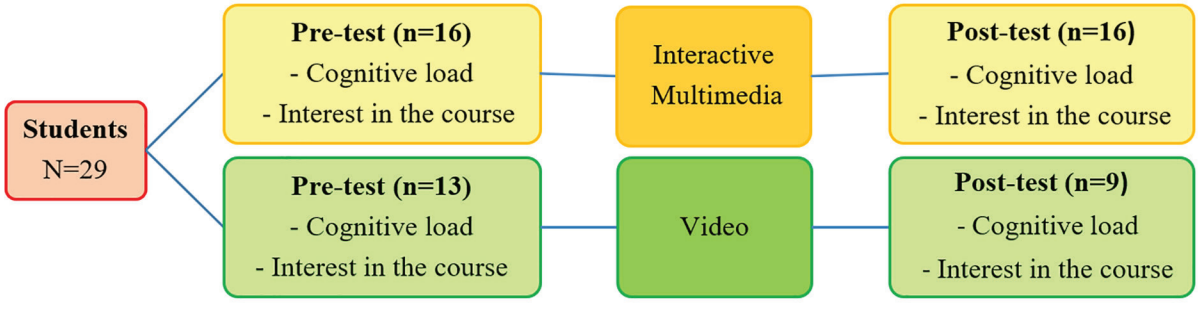

Figure 1: Schematic view of the research design

Validity and Reliability - Previous studies by Paas (1992) and Paas and van Merriënboer (1994) reported Cronbach's alpha values of 0.90 and 0.82, respectively (23). In this study, the Content Validity Index (CVI) for the questionnaire was 0.89, confirming its acceptable validity and reliability (23).

b) Course interest survey (1993): Created by Keller and Sobia in 1993, this survey consists of 34 questions rated on a 5-point scale, where 1 means false, 2 somewhat true, 3 moderately true, 4 mostly true, and 5 completely true. This questionnaire consists of four key components: Attention (items 1, 4, 10, 15, 21, 24, 26, 29), Communication (items 2, 5, 8, 13, 20, 22, 23, 25, 28), Assurance (items 3, 6, 9, 11, 17, 27, 30, 34), and Satisfaction (items 7, 12, 14, 16, 18, 19, 31, 32, 33). A higher score indicates greater interest in the course (24). This questionnaire was selected due to its emphasis on essential factors that significantly influence learning, such as attention, communication, trust, and satisfaction. Each of these components plays an important role in fostering motivation and creating an optimal learning environment. For instance, when students are attentive in online learning contexts, their engagement and learning improve. Likewise, effective interaction between instructors and students in virtual classrooms greatly enhances the educational experience. Trust also matters—when students feel confident that their skills match the course content, learning outcomes are better. Finally, higher satisfaction with online classes and positive experiences increase the likelihood of successful learning.

Validity and Reliability - According to prior research conducted by Haddadi in 2013, the questionnaire's content validity has been confirmed (25). In the current research, Cronbach's alpha values were 0.84 for both the attention and communication components, 0.81 for assurance, 0.88 for satisfaction, and 0.95 for the overall instrument (26). The CVI of the questionnaire was calculated to be 0.86, confirming the acceptability and reliability of the tool for sampling purposes. Additionally, to determine the sample size, an alpha level of 0.05 and an effect size of 0.50 (according to Cohen's d) were applied (27).

Data Collection

Data collection was performed separately for each group. Prior to the training, students took pre-tests assessing their cognitive load and interest in the course. Upon finishing the training program, the questionnaires were administered again. These questionnaires were distributed electronically through email, with each student receiving a personalized link. Although the questionnaires were anonymous, students used a unique code to identify themselves on both the pre-test and post-test forms.

Data Analysis

Paired-sample t-tests were performed to compare the pre-test and post-test scores within each group. Independent-sample t-tests were utilized to compare the pre-test and post-test scores between the two groups, as well as to compare the post-test scores across the two groups. Data analysis was carried out using SPSS software version 26 and R version 4.1.1, including the RVAideMemoire package.

Ethics - All participants were fully informed about the study's objectives and procedures and gave their consent before participating. They were assured that their data would remain confidential, be used only for research purposes, and would not affect their academic results. All procedures were conducted under the guidance of the Ethics Review Board of Islamic Azad University, Arak Branch, Iran.

Results

Demographic Characteristics

Among the 29 participants in the study, 25 finished both the pre-test and post-test phases. Within the video-based education group, 4 of the 13 participants withdrew following the pre-test, leaving 9 participants who completed the post-test survey.

To assess whether the interactive multimedia and video-based groups were comparable in terms of demographic factors,

specifically gender and age, a chi-square test of independence was performed. The analysis revealed no significant differences between the two groups regarding age (P=0.06) and gender (P=0.59). The demographic details of the participants, including age and gender, are provided in Table 1.

Analytical findings

Cognitive Load: Paired-sample t-tests were used to compare the pre-test and post-test cognitive load scores within each group. The results showed that the post-test scores in both groups were significantly higher than their respective pre-test scores (P=0.01). Independent-sample t-tests indicated no significant difference between the pre-test scores of the two groups (P=0.63). Similarly, there was no significant difference between the post-test scores of the two groups (P=0.75). These findings suggest that both methods have a similarly positive effect on students' cognitive load (Table 2).

Course Interest: The students' enthusiasm for the course was assessed in two groups across four subcomponents: Attention, Confidence, Satisfaction, and Relationship. Initially, pre-test and post-test scores were analyzed for each group separately, followed by a comparison of scores between the groups using independent-sample t-tests (Table 3).

The findings of this study indicated that both the interactive multimedia and educational video groups experienced a significant change in cognitive load from the pre-test to the post-test (P<0.01). However, no significant differences were identified between the two groups at either the pre-test or post-test stages (P>0.05). In terms of attention, both groups showed significant improvements between the pre-test and post-test (P<0.05). Specifically, the interactive multimedia group showed a significant change (P=0.03), as did the video-based education group (P=0.04). Nonetheless, no significant differences were observed between the groups at the pre-test (P=0.57) or post-test (P=0.46).

For the relationship variable, the interactive multimedia group exhibited a significant change from pre-test to post-test (P=0.01), while the video-based education group did not show a significant change (P=0.12). Moreover, there were no significant differences between the two groups at either the pre-test or post-test phases (P>0.05).

For confidence, significant improvements were observed in the interactive multimedia group between the pre-test and post-test

Table 1: Demographic characteristics of participants

Variables	Groups	Categories	Frequency (Percentage)	P value
Gender	Interactive multimedia	Male	2 (22.20)	0.59
		Female	7 (77.80)	
	Video	Male	1 (6.30)	
		Female	15 (93.80)	
Age	Interactive multimedia	Less than 25 years	2 (22.20)	0.06
		25 to 30 years	3 (33.30)	
		Above 30 years	4 (44.40)	
	Video	Less than 25 years	8 (50)	
		25 to 30 years	7 (43.80)	
		Above 30 years	1 (6.60)	

Table 2: Comparison of pre-test and post-test scores of students' cognitive load between two groups

Variable	Type of training	Pre-exam	Post-exam	P value
		Mean±(SD)	Mean±(SD)	
Cognitive load	Interactive multimedia	25.66±(5.85)	16.11±(2.80)	0.01
	Video	24.75±(5.80)	15.50±(3.24)	0.01
	P value (Between groups)	P=0.75	P=0.63	--

SD: Standard Deviation

Table 3: Comparison of pre-test and post-test scores of students' interest in the course between two groups

Variable	Component	Type of training	Pre-exam	Post-exam	P value
			Mean±(SD)	Mean±(SD)	
Interest in the course	Attention	Interactive multimedia	21.44±(2.29)	24.66±(4.63)	0.03
		Video	22.37±(3.09)	25.93±(4.25)	0.04
		P value (Between groups)	P=0.57	P=0.46	--
	Relationship	Interactive multimedia	26.11±(2.75)	30.55±(3.87)	0.01
		Video	25.62±(3.50)	30.68±(4.01)	0.12
		P value (Between groups)	P=0.79	P=0.97	--
	Confidence	Interactive multimedia	22.88±(4.16)	24.55±(3.43)	0.04
		Video	23.00±(2.52)	25.06±(2.88)	0.06
		P value (Between groups)	P=0.82	P=0.63	--
	Satisfaction	Interactive multimedia	27.66±(3.12)	30.33±(5.12)	0.03
		Video	28.12±(3.38)	30.25±(4.72)	0.78
		P value (Between groups)	P=0.45	P=0.91	--

SD: Standard Deviation

(P=0.04), whereas the educational video group showed no significant change (P=0.06). Comparisons between the groups revealed no significant differences at both pre-test and post-test stages (P>0.05).

Regarding satisfaction, the interactive multimedia group experienced a significant change from pre-test to post-test (P=0.03), unlike the educational video group which showed no significant difference (P=0.78). Additionally, no significant differences emerged between the groups during the pre-test (P=0.45) or post-test (P=0.91) evaluations.

In summary, both instructional approaches significantly impacted cognitive load and attention. However, only the interactive multimedia method produced significant effects on relationship, confidence, and satisfaction variables, whereas the video-based instruction did not.

Specifically, cognitive load scores decreased significantly from pre-test to post-test in both the interactive multimedia group (from 25.66±5.85 to 16.11±2.80, P=0.01) and the educational video group (from 24.75±5.80 to 15.50±3.24, P=0.01), with no notable differences between groups at either time point (pre-test P=0.75, post-test P=0.63). Regarding course interest and its components, significant increases were found only in the interactive multimedia group for attention (from 21.44±2.29 to 24.66±4.63, P=0.03), relationship (26.11±2.75 to 30.55±3.87, P=0.01), confidence (22.88±4.16 to 24.55±3.43, P=0.04), and satisfaction (27.66±3.12 to 30.33±5.12, P=0.03). The video-based group also showed a significant rise in attention (from 22.37±3.09 to 25.93±4.25, P=0.04). No significant between-group differences were observed for these measures during pre- or post-tests.

Discussion

The present study examined the effectiveness of interactive multimedia-based and video-based virtual education on cognitive load and course interest among postgraduate students in a research methods course.

Findings revealed that both interventions significantly reduced students' cognitive load from pre-test to post-test, with no significant difference between the two groups at any time. Regarding course interest, both groups showed significant improvement in the attention; however, only the interactive multimedia group experienced significant increases across all dimensions of course interest, including relevance, confidence, and satisfaction. No statistically significant differences were found between the groups in any measured variable at baseline or after the intervention. These findings are consistent with previous research suggesting

that multimedia-based instruction—by engaging multiple sensory channels through the integration of text, audio, graphics, and animation—can facilitate learning and reduce cognitive load (10, 14, 16).

Several studies have indicated that video-based and interactive multimedia formats offer chances for self-directed learning, repeated review, and enhanced involvement with the content, which together promote better understanding and memory retention (11, 15, 19). Although some earlier studies have suggested that interactive multimedia is more effective than video alone in lowering cognitive load and improving learning outcomes (32), our study did not find a notable difference between these two methods regarding cognitive load reduction. This outcome could be explained by the fact that participants in both groups were provided with the same instructional material and access to flexible, learner-centered virtual environments, enabling them to control their own learning process and manage cognitive demands efficiently (11, 14, 16).

In terms of course interest, the greater improvement observed in the interactive multimedia group—especially in relevance, confidence, and satisfaction—supports Keller's ARCS model, which emphasizes the importance of attention, relevance, confidence, and satisfaction in sustaining student motivation (24). This is consistent with studies indicating that interactive elements like immediate feedback and active learner involvement more effectively boost students' motivation and engagement compared to passive video watching (10, 16, 26).

The impact of interactive multimedia on students' interest in the course aligns with the results of many prior studies (2-8, 10-12, 14, 28-32). These studies collectively emphasize the important role that multimedia learning plays in boosting student engagement and enthusiasm. It is difficult to expect high student achievement in classrooms that depend solely on traditional teaching methods without incorporating innovative instructional tools, as such environments are often rigid and unexciting. In these situations, students who lack interest in the subject may find their educational needs unmet, resulting in disengagement for both learners and teachers. With progress in educational science and learning theories, the use of multimedia and video-based teaching approaches has shown to be more effective, leading to improved student outcomes. The strength of educational multimedia is its capacity to convey information through various modes, enabling students to understand abstract ideas in written form and then observe these concepts in action through animations or videos.

Considering the variety of learning styles and involving several sensory pathways can assist in lowering cognitive load (19). This diversity not only enhances the learning experience but also promotes a deeper level of understanding, making it crucial for universities and educational organizations to design learning processes that encourage advanced comprehension while reducing mental effort (12, 16). In fact, the decreased cognitive load observed in both groups suggests that the key element might be the flexibility and ease of access provided by virtual learning environments rather than the particular instructional approach used. Enabling students to manage their own learning pace, review materials whenever necessary, and tailor their study sessions to their personal preferences likely contributes significantly to reducing cognitive stress (33).

However, the increased interactivity in multimedia-based teaching seems to provide clear motivational benefits, demonstrated by the wider enhancements in various aspects of course interest. These interactive features probably created a more engaging and encouraging learning atmosphere, which helped boost students' sense of relevance, confidence, and satisfaction (34, 35).

An additional key point is that lowering cognitive load can have a positive impact on students' satisfaction and motivation toward learning. Incorporating new technologies like educational videos helps students learn more

effectively and increases their enjoyment of the learning experience. This heightened satisfaction subsequently supports their academic success and overall development. Therefore, it is important to consider the effects of integrating new technology and multimedia educational tools on students. Effective learning aims to generate both intrinsic and extrinsic motivation. A skilled teacher can use extrinsic motivators to enhance intrinsic motivation, thereby boosting students' engagement through the use of educational multimedia (16, 19, 34). This method can improve students' confidence and satisfaction within their academic setting by linking video content directly to learning goals, which helps maintain their focus in class. Differences between the current findings and other research may be attributed to variables such as group size, instructor influence, the quality of teacher-student relationships, and the nature of the course being taught (4).

Conclusion

This study demonstrated that both interactive multimedia and video-based virtual instruction significantly reduced cognitive load and increased course interest among postgraduate students in a research methods course. While both methods were effective, interactive multimedia showed greater benefits in enhancing all dimensions of course interest—attention, relevance, confidence, and satisfaction—compared to video-based instruction, which primarily improved attention. These findings suggest that incorporating interactive and multisensory elements in virtual learning environments not only facilitates deeper learning by reducing cognitive demands, but also fosters greater student engagement and motivation. Given the growing reliance on virtual education, especially in higher education settings, the integration of interactive multimedia tools can be a valuable strategy to optimize learning outcomes and student satisfaction. Future research with larger and more diverse samples is recommended to further validate these results and explore their applicability across different disciplines.

Limitations and Suggestions

This study had several limitations. First, there was no control group receiving traditional face-to-face instruction; both groups participated in different forms of virtual intervention, which limits direct comparison with conventional teaching methods. Second, the sample size was small and selected through convenience sampling from a single university, which may affect the generalizability of the findings. Third, the study was conducted within the context of a single course (research methods) and educational level (postgraduate), so the results may not be applicable to other disciplines or levels of education. Finally, the reliance on self-reported measures for cognitive load and course interest may introduce response.

Future research should include a larger and more diverse sample, ideally using randomized sampling methods and multiple educational institutions, to enhance the generalizability of the findings. It is also recommended to include a control group receiving traditional face-to-face instruction to better compare the effectiveness of virtual and conventional teaching methods. Additionally, studies across various courses and educational levels can help determine whether the benefits of interactive multimedia and video-based instruction are consistent in different contexts. Employing objective measures alongside self-report questionnaires may further strengthen the validity of the results. Finally, exploring the long-term effects of these educational interventions on learning retention and academic performance is suggested.

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Authors' Contribution

All authors participated in developing the study concept. ZS managed the research design, sampling and data analysis, whereas

SM carried out the interventional procedures. SM supervised the implementation of the research, conducting tests, and writing the research. ZP provided advice and guidance in the research implementation process. Each author reviewed the final version, approved its submission, and takes full responsibility for the article's content and authorship.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethical Considerations

The study adhered to ethical research principles involving human participants, including informed consent, confidentiality, anonymity, and voluntary involvement. All participants were clearly informed about the study's purpose and procedures and took part only after providing their consent. They were assured that their information would remain confidential, used exclusively for research purposes, and that their responses would have no effect on their academic performance or evaluation. This research received approval from the Ethics Review Board of Islamic Azad University, Arak Branch, Iran, under the ethics code IR.IAU.ARAK.REC.1401.096.

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Availability of Data and Materials

Any materials used in this study can be accessed by contacting the authors directly. Where applicable, additional data and materials are included within the article.

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