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Evaluation of the Effectiveness of Museum Education in Virtual Environment with 360° Videos

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Abstract: *This study aims to evaluate the impact of virtual museum applications incorporating 360° videos on student achievement levels. In this context, a specialized educational environment was designed using 360° videos in a museum education course, and the effects on learning achievements were examined. Additionally, students' perceptions of the developed environment were assessed. Employing a mixed-methods approach, the research engaged both quantitative and qualitative methodologies. The sample consisted of students majoring in elementary education (N=32) and preschool education (N=29). The quantitative data collection process followed an experimental model with a post-test control group and a randomized design. Qualitative data were gathered through semi-structured interviews reflecting student opinions. The research findings indicate that virtual museum applications positively influence student achievement levels, particularly noting an enhanced interaction with applications incorporating 360° videos. Moreover, qualitative findings support that students perceive such museum education activities positively, indicating a positive impact on the learning process. Based on the results of this study, the following recommendations are proposed for the effective implementation of virtual museum education with 360° videos: Firstly, design virtual museum activities that align with learning objectives and actively engage students. Secondly, it is crucial to instruct students in navigating virtual museum environments using 360° video technology. Additionally, efforts should be made to provide accessible virtual museum experiences for all students. Future research endeavors may delve into a more detailed exploration of the long-term effects of 360° videos in virtual museum education on student learning and engagement. Furthermore, researchers could broaden their perspective by integrating virtual museum education with other teaching formats, such as field trips and hands-on activities.*

Keywords: *360 degree videos; museum education; students' perception; virtual environment; mix method.*

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Introduction

360-degree videos have become increasingly popular in educational settings due to their ability to provide an immersive learning experience that can enhance student engagement and understanding (Ferrari & Medici, 2017; Parmaxi, 2020). While the term "360-degree video" is most commonly used to refer to this technology, it is also known by other names, such as "spherical video" and "VR video" (Ye et al., 2021).

These videos, which offer the user original images, are created by combining images taken with different cameras to form a "spherical" field of view by using special software (Zulkiewicz et al., 2020). The fact that 360-degree videos have a stereoscopic screen feature can offer a wide viewing angle to the audience (Ferrari & Medici, 2017). Compared to two-dimensional videos, 360-degree videos can give the user a greater sense of depth and also create multi-directional panoramic digital content (Argyriou et al., 2020). 360-degree videos can be viewed in a variety of ways, including on a traditional monitor or through a virtual reality headset (Pirker et al., 2020). It can also be monitored by suitable devices such as head mounted displays (HMDs), cell phones, tablets and computers. These videos are viewed through devices called HMDs. These devices consist of two small screens in front of the user's eyes and a type of goggles or helmet used for virtual reality experiences. Thanks to these devices, the user can watch 360-degree videos and feel as if they are there. Unlike traditional videos, which have a fixed perspective, 360-degree videos allow viewers to pan and tilt the view continuously in all directions, creating a more immersive experience (Liu et al., 2020).

Cell phones and tablets can also be used to watch 360-degree videos. For this, the device should first have a suitable 360-degree video player application. Using the device's motion sensors, the view of the video can be controlled. In addition, computers are able to be used to play these videos. At this point, specialized 360-degree video player software should be utilized. This software can allow the use of input devices such as a mouse or keyboard to control the view of the video (Argyriou et al., 2020). In recent years, it is seen that the interest in these videos has increased due to the introduction of features related to 360-degree videos on platforms such as Google, Facebook, Youtube and Vimeo, and the cheap and easily accessible devices (HMD, mobile devices, etc.) that enable virtual reality experience (Hanhart et al., 2018; Shadiev et al., 2022). Although some educators claim that these videos are costly to create (Fraustino et al., 2018; Shadiev et al., 2022), Jiang et al., (2019) stated that this video technology is easy to use and

greatly reduces the cost and time associated with content development. Educators state that learning environments created with 360-degree video technology are effective in overcoming problems related to time and space. They also state that through these videos, the physical accessibility of normally inaccessible environments can be increased (Geng et al., 2021; Liu et al., 2020).

Previous research on the use of 360-degree videos in the learning-teaching process has found that they can have a positive impact on student learning (Okada et al., 2019; Roche & Gal-Petitfaux, 2017). These videos are accessible on a variety of devices, making them easy for students to interact with. With 360-degree videos, students can choose which part of the image to focus on, allowing them to access personalized content (Okada et al., 2019). Additionally, 360-degree videos are thought to be effective in keeping students engaged and motivated (Liu et al., 2021; Vrbik & Vrbik, 2017). Finally, research suggests that 360-degree videos can be useful for teaching abstract concepts and that students have more positive impressions of lessons that incorporate live graphics (Funk et al., 2019; Rupp et al., 2019).

The fact that 360-degree videos offer an authentic learning process to the user allows the utilization of these videos in many fields such as sports sciences, medical sciences, linguistic sciences (Shadiev et al., 2022). Alternatively, related research also emphasizes the importance of the increasing use of digital tools such as 360-degree videos, especially in art, architecture and museum education (Loddo, 2021). It has been determined that the utilization of 360-degree videos in museum education has many advantages in literature. For example, these videos can make students feel like they are taking a real tour in the museum (Adnan, 2020; Reyna, 2018). It also allows students to gain a free experience by visiting the museum from any angle they wish (Yusof et al., 2019). These videos, which make learning more fun, can also be effective in helping students concretize abstract concepts in the museum and reinforce their learning more easily (Ferdig & Kosko, 2020). These videos can also provide an ideal medium for people who do not need to be physically present to visit museums. This makes it easier to access the museum from anywhere in the world (Christ, et al., 2017). In this context, it is thought that it is very crucial to apply 360-degree videos, which have a positive effect on the formation of permanent learning, within the scope of virtual activities in museum education courses. It is believed that virtual museum applications to be realized with these videos can also positively affect the efficiency of museum education courses (Kırksekiz et al., 2020). A review of the literature suggests that while many virtual reality environments have been developed (Giangreco et al., 2019;

Schweibenz, 2019; Takeuchi et al., 2019), research on virtual museum applications specifically designed using 360-degree videos is more limited. It has been observed that the researches prepared in this field are generally prepared on the effects of tours with 360-degree video technologies on user experiences in museums (Kalving et al., 2022). On the other hand, it was also found that there are researches on the use of 360-degree photo/video and virtual reality (VR) technologies (Loddo, 2021).

The literature review reveals that there was no research in which students determined the effectiveness of the museum education course of activities carried out in a virtual environment supported by 360° 3D videos. Within the scope of this research, it is believed that virtual applications to be realized with 360-degree videos can be effective on students' perceptions of the museum education course and fill the gap in this field.

Related Studies

A review of the literature reveals that the majority of applications using 360-degree videos are in the education field. For example, Vallade et al., (2020) aimed to determine the factors affecting university students' behavioral intentions to adopt virtual reality glasses and 360-degree videos for public speaking rehearsals. The study group of the research, which was conducted as a longitudinal study with a mixed design, consisted of 86 students from 5 classes studying at Southern University and taking the Simple Communication course. According to the findings of the study, students think that virtual reality goggle technology created with 360-degree video provides ease of use for public speaking. However, their intention to adopt this technology was found to be relatively low.

Berns et al., (2019) aimed to determine the effect of this application on language learning by developing a mobile application to increase students' skills in language learning by interacting with 360-degree videos. The study group of the research, which was conducted with a quasi-experimental design, consisted of 24 university students taking German courses. During the implementation process, students were allowed to interact with the 360-degree videos and the mobile application developed with virtual reality glasses. In addition, the focus was on improving students' speaking and pronunciation skills, which they usually have difficulty in language learning. As a result of the research, it was stated that the use of 360-degree videos together with a speaking tool is suitable for strengthening students' foreign language proficiency and has a high potential to focus on language in the learning process and thus facilitate language learning.

Walshe and Driver (2019) investigated the use of 360-degree videos in teacher education. Their study found that 360-degree video applications were highly effective in microteaching and supported pre-service teachers' self-efficacy. The authors also emphasized the potential benefits of using 360-degree videos in teacher education.

Repetto et al., (2021) compared the effectiveness of 360° videos with standard videos in second language learning. The results showed that students who were trained with 360° videos had more video views and learned more vocabulary than students in the control group. They also stated that 360° video tutorials can be applied in ecological learning environments as supportive learning tools for homework work.

An exploratory study by Wu et al. (2019) investigated the impact of Spherical Video-based Virtual Reality (SVVR) on elementary school students' problem-solving skills in science lessons. Results showed that SVVR had a positive impact on students' problem-solving skills, and suggested that SVVR integration may have differential effects on students with different learning attitudes.

Lin et al. (2021) investigated the impact of a virtual reality (VR) guide on university students' situational interest and cognitive load in a library. The experimental group used wearable spherical video-based VR devices, while the control group used tablets to learn about the library's functions. The study found that the experimental group reported higher levels of novelty and challenge (subdimensions of situational interest) and higher levels of related cognitive load.

Chang et al. (2020) investigated the effectiveness of spherical video-based virtual reality (SVVR) in helping fifth-grade students learn natural geomorphological knowledge using an experimental design. The control group used a traditional SVVR learning system. No significant differences in learning achievement or motivation were found between the experimental and control groups. However, students in the experimental group outperformed those in the control group on the in-depth knowledge test.

When the researches prepared in the field of museums are examined, it is seen that the researches mostly focus on the effects of tours with 360-degree video technologies on user experiences and the use of 360-degree photo/video and virtual reality (VR) technologies. For example, in the research prepared by Loddo (2021), the effects of these videos and virtual reality applications on architectural education were investigated.This mixed-method study examined how digital technologies can increase awareness of architectural education and improve future museum designs. The findings of the study revealed that digital tools positively affected students' museum

awareness and perceptions of architectural education. Students became more interested and motivated towards the lesson through the applications.

Kalving et al., (2022) investigated the effects of remote museum tours with 360 video technologies on user experiences. In the study, the effects of 360-degree video viewing used through a laptop environment and a 360-degree virtual reality video experienced through a head-mounted device were compared. According to result, it was revealed that the virtual reality application was more effective in users' perceptions.

When the related researches are examined, it is seen that the researches prepared in the field of education mostly focus on the effects of 360-degree videos on students in the learning-teaching process. Within the scope of the studies, the effects of the videos on students' perceptions, skills, learning styles and self-efficacy were evaluated. As a result, it is understood that there are more studies on the use of 360° 3D videos in education, but there are very limited studies on the use of these videos in museum education.

The purpose of the research

The purpose of this study was to determine and evaluate the effectiveness of museum education in a virtual environment supported by 360° videos. The following research questions were addressed in this study:

1. Did museum education with 360° videos make a significant difference on students' learning achievement?
2. What are the students' perceptions of museum education with 360° videos?

Methodolgy

Research Design

The study used a mixed-methods approach, which combines quantitative and qualitative data collection and analysis to provide a more comprehensive understanding of the research phenomenon. This approach allows researchers to corroborate findings from different methods, resulting in stronger and more credible results (Yıldırım & Şimşek, 2016). As an experimental design, one of the real experimental designs; post-test control group randomized design was applied. In this research design, the study group is randomly divided into two groups, experimental and control, and the scale is applied only after the experiment (Büyüköztürk, 2008).

Students were randomly assigned to the experimental group (N=30) and the control group (N=31) in the first week. Starting from the second week, the experimental group students were trained in a virtual environment supported by 360° 3D videos while the control group students were trained in a virtual environment supported by 2D videos. At the end of the five-week training period, an achievement test was applied to both groups. Furthermore, the experimental group were individually interviewed for the 360° 3D videos. The research design is shown in Figure 1.

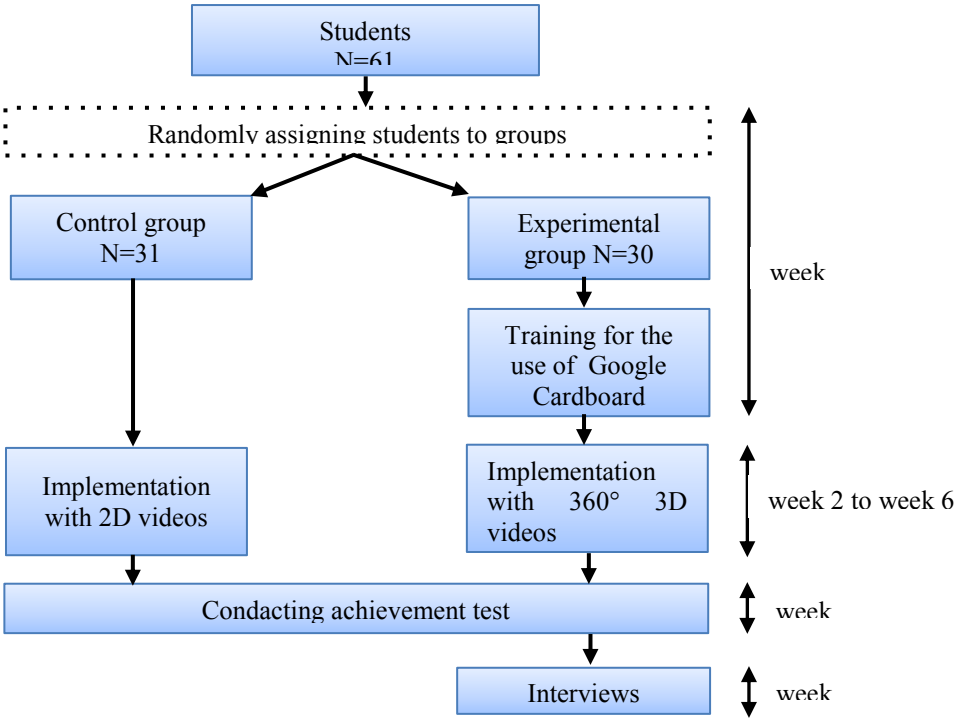


Figure 1. The research design.
Source: Authors' own conception

In addition, the approval for this study was obtained from the Educational Sciences Ethics Committee affiliated to the Near East University Scientific Research Ethics Committee for the ethical permission of the research.

Participants

The study was conducted in the fall semester of 2021-2022 with N=32 classroom teaching and N=29 preschool teaching students enrolled in the museum education practices course. There were N=31 students in the control group and N=30 students in the experimental group (Table 1). In the control group, the lessons were conducted with 2D videos. However, the lessons with the experimental group were taught using 360° 3D videos. The students in the experimental group had no previous experience with 360° 3D videos. The implementation of both groups was carried out by the same trainer.

Table 1 *Distribution of the number of students forming the study groups according to departments*

Groups	Classroom teaching	Preschool Teaching	Total
Experimental	13	17	30
Control	19	12	31

Source: Authors' own conception

Data Collection and Tools

The aim of this study was to determine whether there was a difference in learning achievement between students. To achieve this aim, a learning achievement test was applied to both groups after the implementation. The quantitative data of the study were analyzed using an independent sample t-test. As part of the study, museum education activities were designed using Edpuzzle, Google Arts and Culture applications, and 360° 3D videos from virtual applications to engage students with artifacts from the British Museum, Hermitage Museum, and Louvre Museum.

Following the implementation of museum education activities, a semi-structured interview form was utilized to gather students' perceptions regarding the effectiveness of the educational intervention. The qualitative data from the interviews were analyzed using content analysis. In the first stage, an expert transcribed the interviews and examined the transcripts. In the second stage, the data were coded separately based on the groups of words expressed by the participants. The data were categorized based on the similarities between the codes, which led to the formation of themes. To facilitate the analysis, each student was assigned a unique code number. In the third stage of analysis, two museum education experts, two educational program experts, and two educational technology experts were involved in the process. They compared the predetermined themes selected by the

researchers and verified whether the identified codes represented the conceptual themes. In this stage, codes were categorized as "Agreement" or "Disagreement." The qualitative data obtained were subjected to reliability calculation using Miles and Huberman's (1994) formula of Agreement Percentage = Agreement / (Agreement + Disagreement) x 100. The study revealed that 9 out of the 11 codes selected by the researchers were approved, resulting in an 81.8% agreement on the coding's suitability. Additionally, a comparison of the results obtained through a content analysis conducted by an external evaluator demonstrated an 80% agreement, indicating the high reliability of the coding. Experts in qualitative research were consulted during the interpretation of the semi-structured interview data to ensure the reliability of the coding processes and the themes derived from them. Thus, the expert opinions contributed to the establishment of the coding's reliability and ensured the accuracy of the themes derived from the data analysis.

Learning Achievement Test

In this research, the researchers developed a multiple-choice achievement test to assess the impact of museum education on students within a virtual environment augmented by 360° 3D videos. The decision to use a multiple-choice achievement test was made to ensure content validity and enhance the objectivity of the scoring process while measuring the outcomes of the study. To ensure the content validity of the achievement test, the first stage involved examining each achievement of the "museum hunt and artifact analysis" unit within the "museum education" course. A specifications table was then created to illustrate the distribution of these achievements and their relation to the content. Subsequently, the achievement test draft was developed by constructing questions to measure each achievement. The draft test included six questions for each achievement, totaling 35 questions. Content validity of the questions was ensured through expert evaluation, seeking the opinions of two language experts, two museum education subject area experts, and two assessment and evaluation experts. Five unsuitable items were removed from the test based on the language structure of the questions and their alignment with course outcomes and student suitability. A pilot study was then conducted on a separate group from the research group of 33 classroom-teaching students who took the museum education course in the previous year (2020-2021 fall semester). The achievement test comprised 30 questions with four options. To determine the test and item statistics of the piloted draft achievement test, item difficulty and item discrimination indexes were

calculated using the SPSS data analysis program. Following the pre-application of the achievement test, the internal consistency reliability coefficient of the test, expressed as the KR-20 value, was calculated to be 0.89. Büyüköztürk (2022) suggest that a KR-20 value of 0.70 or higher indicates a reliable structure for tests, and that the closer the value is to 1, the greater the test's reliability. Given that the developed test has a KR-20 value of 0.89, it can be confidently stated that the test has a highly reliable structure. However, the average difficulty index of the test was determined to be 0.57. According to Atılgan, Kan, and Doğan (2019), the average difficulty index should be around 0.50 or higher. In this regard, it can be concluded that the test has a medium difficulty level based on the calculated value of 0.57. Since the difficulty index range of the items should fall between 0.40 and 0.80, it was decided to remove certain items from the test (Büyüköztürk, 2022). Moreover, the discrimination indexes of the items were calculated and only those with a range between 0.30 and 1.0 were retained in the test (Büyüköztürk, 2022). Based on this finding, questions with an item difficulty index falling outside the range of 0.20 and 0.80 were excluded from the test.

Table 2 *The number distribution of final achievement test items based on the measured outcomes.*

Item	Question distribution
1. Implements the stages of the museum hunt activity.	5
2. Comprehends the stages of the works exhibited in the museum.	5
3. Distinguish the production materials of the works exhibited in the museum.	5
4. Evaluates the artistic features of the works in the museum.	5
5. Explains the historical features of the artifacts in the museum.	5

Source: Authors' own conception

Consequently, the final achievement test comprises a total of 25 questions. Table 2 presents the number distribution of the questions in the test according to the achievements they assess. Specifically, the test includes 5 questions for each of the five distinct achievements related to the "Museum Hunt and Artifact Analysis" unit.

Semi-Structured Interview Form

A semi-structured interview form was developed by the researchers, which included questions based on a literature review of virtual environments in museum education. The virtual environments, specifically

360° 3D videos of museum settings, were chosen based on their ability to engage students and facilitate museum educational activities. Draft questions were developed based on these considerations and subsequently reviewed by experts (N=5) to ensure content validity. The form was further evaluated by linguists (N=2) and measurement specialists (N=3) before its final version was produced. The interview question were indicated in Table 3.

Table 3 *Semi-structured interview form Question*

No	Question
1	What are your thoughts on museum education using 360° 3D videos?

Source: Authors' own conception

Experimental Procedure

Experimental Group

In the initial week of the implementation phase, the students in the experimental group were briefed on the utilization of 360° 3D videos and Google Cardboard with smartphones. The use of Google Cardboard was deemed necessary as smartphones alone cannot deliver a stereoscopic image for 3D videos. By partially blocking out the external environment, Google Cardboard creates a stereoscopic environment for the user to watch the 360° video. Moreover, to enhance the level of immersive and due to the lack of VR glasses for each student, a combination of a smartphone and Google Cardboard was employed (as illustrated in Figure 2).

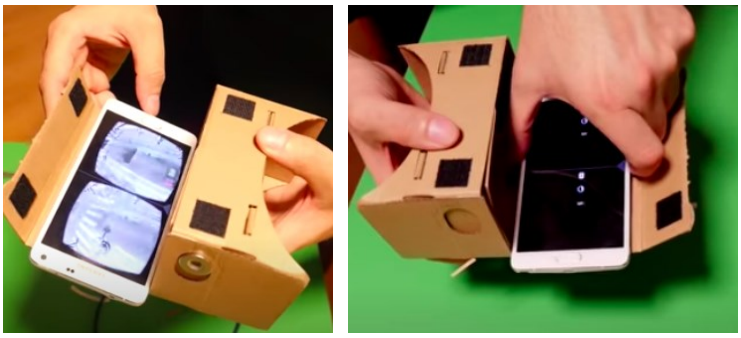


Figure 2. Using Google Cardboard with a smartphone (Source: Authors' own conception)

In the process of selecting the museum for the study, museums with comprehensive collection content and 360° 3D video tours were chosen. Specifically, the Louvre Museum, the British Museum, the Hermitage Museum were included in the study. The researchers planned museum education activities based on the contents of the museums' works, which

included historical information, the characteristics of the works, and their intended purposes. Furthermore, the implementation stages were reviewed and reorganized in accordance with expert opinions and suggestions. The activities lasted a duration of 5 weeks and were conducted through the Moodle platform, which provided access to Edpuzzle videos and links for students to participate in the activities and share relevant applications.

To foster students' research skills and critical and analytical thinking skills, the "Museum Hunt" activities were initially conducted using the Google Arts & Culture application. The researcher prepared worksheets containing questions about the artworks and activities for the museum hunt (Figure 3). The report generated from the museum hunt activity included questions such as "What is the name of the artwork?", "What is the date of the artwork?", "What was the purpose of its creation?", "What is its contemporary usage?", and "What are the distinctive features of the artworks?"





The name of artwork :	
The date of artwork:	
What for am I using?	
For which aims am I using today?	
What are the similarities with the example of today's artwork?	
What are the different aspects of the present day's artwork?	

Figure 3. Sample working paper (Source: Authors' own conception)

The students accessed the worksheets of the Google Arts & Culture application via the three-dimensional environments of the museums (as shown in Figure 4), and then answered the questions. This activity was designed and conducted for a variety of works, including sculpture, painting, relief printing, and vase samples, in three different museums.

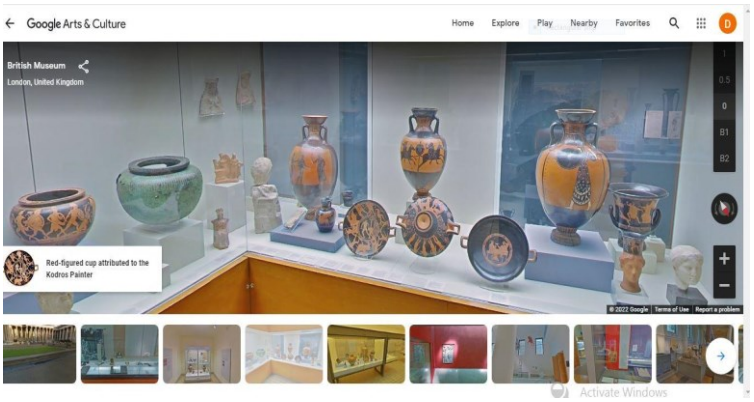


Figure 4. Google Arts & Culture Application
Source: Google Arts & Culture

Students shared their answers to the questions through homework links created on Moodle (See Figure 5).

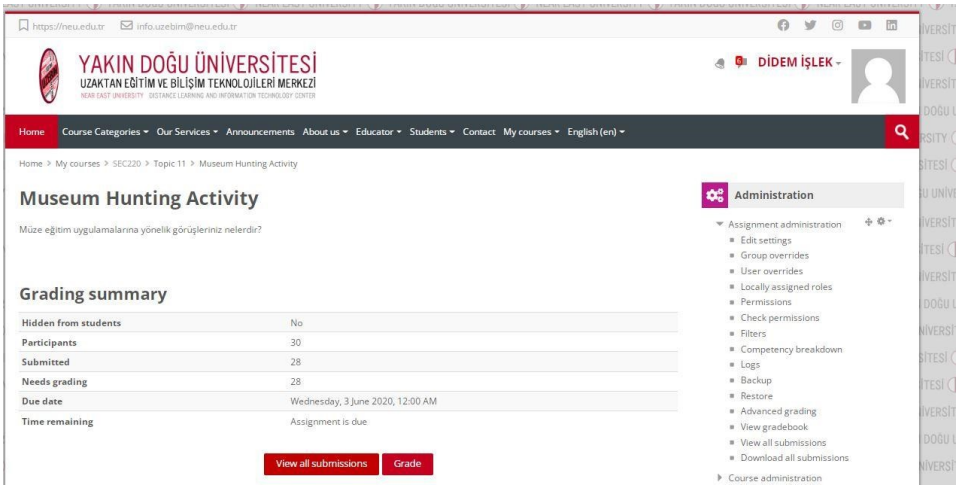


Figure 5. Moodle Platform
(Source: Moodle, https://uzebim.neu.edu.tr/)

In the second stage of the implementation, the works exhibited in the 360° 3D videos of the museums were narrated and questions related to the works were incorporated into the videos. This process was achieved using Adobe Premiere Pro software (refer to Figures 6 and 7). The students viewed the videos by placing their smartphones inside the Google Cardboards.

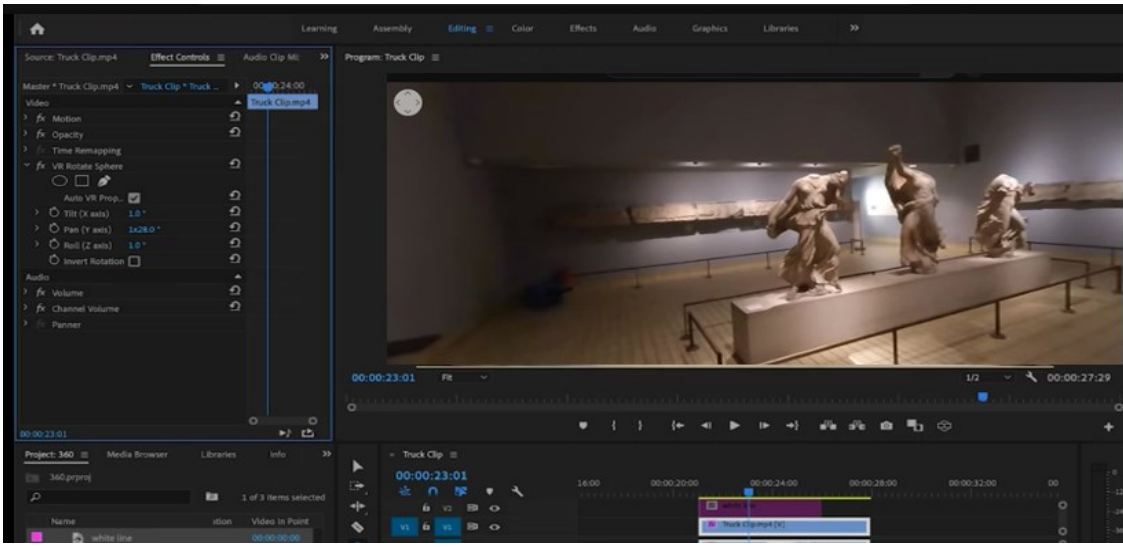


Figure 6. British Museum Tour (VR 360 Video) (Source: MyVRWorld, 2019)



Figure 7. Grande Galerie - Musée du Louvre (Source: Moreno, 2022).

During the second stage of the implementation, general information about the artefacts displayed in museum environments was conveyed to the students using the storytelling method, in which the artefacts were given a voiceover (Figure 8). For example, an oil painting exhibited in the Hermitage Museum by Leonardo Da Vinci introduced itself with the following statement: "Hello, I am an oil painting exhibited in the Hermitage Museum. I was illustrated by Leonardo Da Vinci, the famous master of the Renaissance period. Among the sample quiz questions added was 'What is

the main feature of the period?'. I was depicted on the subject of Mary and Jesus." Teaching activities were conducted on the subjects of "using virtual teaching environments", "identifying and answering questions about the work exhibited in the virtual museum environment", and "designing and implementing museum hunt activities using the virtual museum environment". These activities are aimed to enhance the student's knowledge about the features of the works, the purpose of their creation and their historical development, and to improve their ability to establish cause-and-effect relationships.

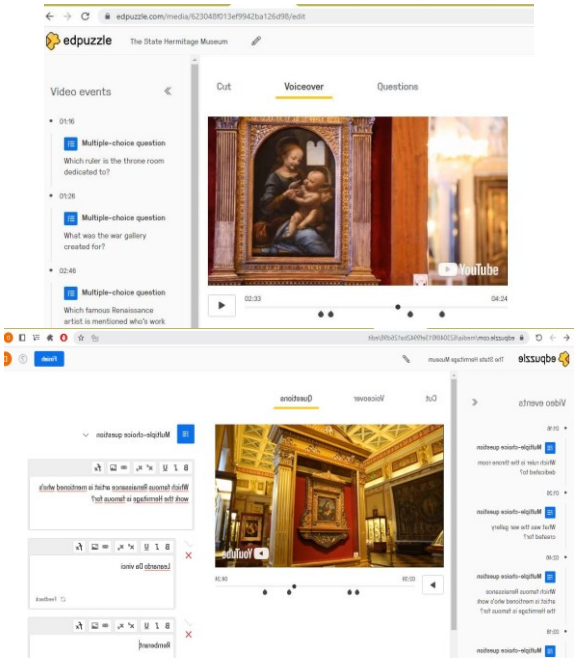


Figure 8. Screenshot from Edpuzzle app
Source: Authors' own conception

In the final stage of the implementation, an achievement test that was developed as part of the study was applied to the experimental group. Additionally, 10-12 minute interviews were conducted with the students in the experimental group to assess their perceptions of the effectiveness of the application. Specifically, they were asked to provide their views on museum education with 360° 3D videos. The students' responses were then evaluated.

Control Group

In the control group, all the activities that were applied to the experimental group were carried out. Museum education activities were carried out by using 2D videos instead of only 3D videos.

Findings

Analysis of learning achievement data

Upon the completion of a five-week implementation period, an achievement test was applied to both groups to assess their learning outcomes. To evaluate the effectiveness of the intervention, an independent samples t-test was conducted on the data obtained from the test, and the resulting statistics were reported in Table 4.

Table 4 *Students' learning achievement*

Group	N	Mean	SD	*t*	*p*
Control	31	64.225	14.536	2.000	0.042
Experimental	30	71.366	12.181		

Significant at the 0.05 level.
Source: Authors' own conception

The analyses revealed a significant difference in learning achievement test scores between the control and experimental groups ($t=2.000$, $p<0.05$), suggesting that the utilization of 360° 3D videos may enhance students' academic performance and learning outcomes.

Student Perceptions of the Effectiveness of Museum Education in a Virtual Environment Supported by 360° 3D Videos

Table 5 presents the perspectives of students in the experimental group regarding museum education activities conducted in virtual environments utilizing 360-degree 3D videos. Student perceptions of qualitative data are categorized into three principal themes. Firstly, general impressions of museum education activities supported by 360-degree videos are presented. Secondly, opinions on the impact of the developed environment on the learning process are outlined. Finally, students' perceptions of the challenges encountered during the application are discussed.

Table 5 *Interview results*

Theme	Coding items	Number of responses (f)
Museum activities supported by 360° 3D Videos.	immersive virtual environment attracts the attention	14
	Opportunity to enjoy while learning	11
	Increasing motivation level	5
Impact on the learning process	Permanent learning	11
	Developing observation skills	8
	Deep learning	6
	Developing research skills	5
Issues	Internet connection problems	17
	Lack of experience in using VR glasses	13

Source: Authors' own conception

In the interviews, students were first asked questions about museum activities supported by 360-degree videos. In the first theme, the majority of the students stated that the museum activities supported by these videos provided an immersive environment and they found this environment very interesting (f=14). In addition, students stated that they learned by having fun (f=11) and their motivation increased (f=5) thanks to these activities. Some student opinions about this theme are as follows;

"… I had an immersive experience thanks to these videos. I focused more on the works, feeling like I was in a museum environment." (S8)

" …it was much more fun than boring materials like 2D videos or looking at pictures of artifacts. I was able to experience the natural environment of a museum I had not been to before, thanks to 360-degree videos." (P27)

"...I interacted more with the artifacts and the museum environment. I was able to carry out the work questions in the discovery report in an active process by using this environment. Thus, my interest and motivation towards museums increased positively." (P13)

Students were interviewed about the effectiveness of 360-degree videos in museum learning and teaching activities. In second theme, the majority of the students stated that this environment provides permanent

learning (f=11). They also stated that they could observe the works better (f=8) and obtain more comprehensive information about the works (f=6) while learning in this environment. In addition, the students also stated that they wanted to do more research on the works (f=5). Some of the student opinions under this theme are given below:

"...I was able to examine the works from different angles. Thanks to being in an interactive environment, I realized that I did not forget the information about the works of art even after weeks." (S7)

"... Examining the artifacts in the museum with 360-degree videos instead of using 2D videos or pictures increased my curiosity about the artifacts. I enjoyed exploring the features of the works on my own." (P21)

"... I was able to turn around his work, seeing the details and examining it again and again. I think that watching the works in this way is more beneficial for my learning." (P16)

"... I spent more time in museums without realizing it, I think I have the necessary knowledge about the artifacts." (S1)

"... I think every museum should have 360 degree videos. So we can visit a museum anywhere in the world as if we had been there." S(30)

Students were interviewed about the challenges they faced in museum activities supported by 360-degree videos. In the third theme, the majority of the students stated that the students had internet interruptions (f=17) during the activity. They also stated that they had problems while using VR glasses (f=13). Some student opinions on these problems are presented below.:

"... it can be annoying to disconnect from the internet while enjoying the museum and concentrating on an artifact." (S4)

"I did not have enough knowledge about how to use VR glasses. I had not experienced. I had some difficulty during use." (P24)

Conclusion & Discussion

It is believed that the results obtained from the conducted research make important contributions to global education in the international platform. It is also thought that the results of the research will make important contributions to the developing field of technology-integrated pedagogy in the context of cultural learning. The study investigates the effectiveness level of 360-degree video use in museum education and evaluates the results of this effect on students' academic achievement and

perceptual reactions. In this context, in this study, in line with the aim of the research, the achievement levels and opinions of the students regarding the use of 360-degree video in museum education were examined.

According to the findings, the experimental group achieved significantly higher scores on the post-intervention learning achievement test than the control group. This result is thought to be due to the fact that examining a work with 360-degree videos enriches students' learning experiences compared to examining a work through only a picture or 2D videos. In this context, the results obtained in line with the first sub-objective of the study reveal convincing evidence supporting the advantages of using 360-degree video in museum education. Students who used this technology had higher academic achievement than other students. The achievement of students who learned with traditional methods was lower than those who learned with 360-degree videos. Previous academic studies support this finding. The integration of immersive technologies such as 360-degree videos is emerging as a crucial facilitator in promoting deeper engagement and comprehension in educational settings (Lin et al., 2019; Vallade et al., 2020; Yusof et al., 2020).

And secondly according to qualitative results of the study illuminates students' positive perceptions of the immersive nature of 360-degree videos in museum education. According to students' views , within the scope of the first theme, it was determined that the majority of them viewed museum education positively with 360-degree videos. Students stated that they felt the immersion effect and experienced a realistic perception of space. It is thought that learning with 360-degree video-generated virtual reality may be appropriate for certain types of learning, such as encouraging empathy, reflection or skill-based knowledge as opposed to concrete or conceptual knowledge. In the research prepared by Rupp et al., (2019), it is stated that 360 degree videos provide an immersive educational experience to the user, and this feature is one of the most important factors affecting the choice of these videos. It is also seen that there are other studies (Argyriou et al., 2020; Chirico et al., 2017; Yilmaz et al., 2015) reporting that immersive educational activities have a beneficial effect on learning. These findings support the findings of the study. However, within the scope of the same theme, it was also determined that the students found the museum activities carried out with these videos entertaining and motivational. At this point, in some studies examining student views, it was reported that when students are taught with 360-degree videos, the lessons become fun (Lee et al., 2017), their motivation increases (Lampropoulo, 2021) and they learn effectively (Rupp et al., 2019).

The results obtained from qualitative data; Within the scope of the second theme, it has been revealed that the students have opinions about permanent and detailed learning, observation and gaining the skills of research on museum activities carried out with 360-degree videos. In parallel with these findings, in the study prepared by Loddo (2021), it was stated that museum activities made with 360-degree videos were effective in students' learning by discovery, observation and development of research aspects. In the research of Walshe and Driver (2019), it was stated that this practice can improve the observation skills of individuals, which is in line with the finding of the study. In the third theme, students reported encountering difficulties in the use of videos in museum education. Despite the benefits of using 360 degree videos in museum education, some difficulties were encountered during the application of this technology. Students reported that they had problems with internet connection problems and using VR glasses. Understandably, the study also acknowledges the challenges associated with the implementation of 360-degree videos in museum education, especially related to technical issues such as internet connectivity and the use of VR goggles. These challenges, reiterated in previous studies (Huber et al., 2017; Johnson, 2018), highlight the need for continuous technological advances to facilitate and optimize the integration of such tools in educational settings.

The results from the study revealed that both quantitative and qualitative data comprehensively demonstrated the effectiveness of 360-degree videos in museum education. Furthermore, the findings not only underline the potential positive impact on students' academic achievement, but also highlight the need for continuous research and improvement of immersive technologies to overcome related challenges and maximize educational benefits on a global scale.

Limitations and future suggestions

There are some limitations within the scope of the research. The most important limitation of the study is that only 61 students participated in this research designed according to the experimental model. This sample size may limit the universality of the research findings. At this point, in order to reduce this limitation, future research should include a larger and more diverse pool of participants. For example, if students from different educational levels, cultural backgrounds and geographically different regions are included in the study, the validity and reliability of the research can be increased. Thus, the results can be generalized more comprehensively. In addition, given the impact of technology on education, future studies could

examine this phenomenon in different virtual environments or platforms, thus enriching the understanding of the effectiveness of museum education in various digital environments. And also based on the results of this study, the following recommendations are proposed for the effective implementation of virtual museum education with 360° videos: Firstly, design virtual museum activities that align with learning objectives and actively engage students. Secondly, it is crucial to instruct students in navigating virtual museum environments using 360° video technology. Additionally, efforts should be made to provide accessible virtual museum experiences for all students. Future research endeavors may delve into a more detailed exploration of the long-term effects of 360° videos in virtual museum education on student learning and engagement. Furthermore, researchers could broaden their perspective by integrating virtual museum education with other teaching formats, such as field trips and hands-on activities.

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