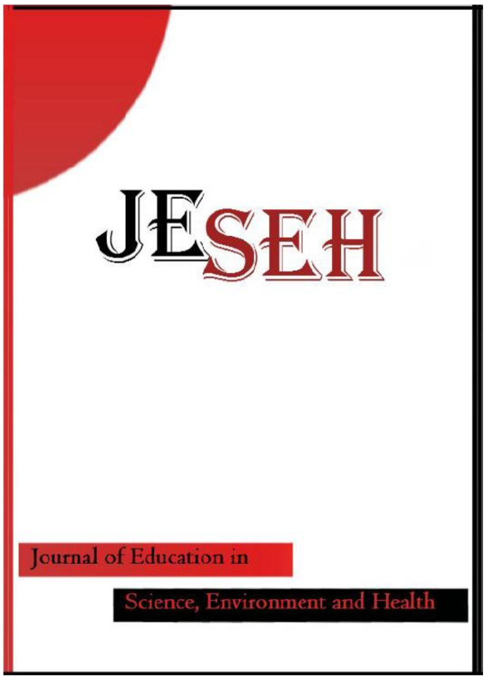

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Abstract

The use of technology in education gained importance in the 21st century and the use of innovative technologies in education-technology integration came to the agenda. This study examines students' attitudes, thoughts, suggestions and opinions about digital hologram, which is one of the innovative technologies. The method used in the study was sequential explanatory approach, which is a mixed research method in which quantitative and qualitative methods are used together. The study was carried out with 418 students from six different public secondary schools affiliated to the Provincial Directorate of National Education in the Aegean Region. During the application process of the study, biodiversity, cells and divisions, DNA and genetic code, systems in our body topics, which are included in the science curriculum of the 5th, 6th, 7th and 8th grades were supported with digital holograms in a five-week period. Digital hologram attitude scale (DHAS) and digital hologram reflection form (DHRF) developed by researchers were used to collect data. Independent samples t-test and one-way analysis of variance (ANOVA) were used in the analysis of the data obtained from DHAS, whereas content analysis was used in the analysis of the data obtained from DHRF. As a result of the research, students' attitudes towards digital hologram were found to be positive. In addition, students' attitudes towards digital hologram did not differ significantly according to gender, grade, and school, but they differed according to science course academic achievement score in favor of students with a score between 85-100. Moreover, students evaluated the digital hologram as a useful tool that can contribute to academic learning and can be used in science class in the topics such as solar system and planets, space research, and living creatures. Based on these results, it is recommended to use the digital hologram at all grade levels and for the topics covered by science curriculum.

Introduction

In the 21st century we are in, changes are experienced in almost every field depending on the development of technology and these are also reflected in the fields such as health, tourism, art and education. Thanks to technological advances especially in the field of education, learning and teaching settings are rearranged and technology is described as a tool assisting education (Dieuzeide, 1971). In this sense, it is considered as an integral part of education and education-technology integration is prioritized especially in science education (Inam, 2004).

Many different technological tools have been used in the education from the past to the present and still continue to be used depending on today's developments. The technologies used in the past, such as overhead projector, computer, simulation are replaced by innovative technologies such as augmented reality, virtual reality and digital hologram (Huang et al., 2016; Ingram & Jackson, 2004). Digital holograms, which are frequently mentioned in the recent periods, attract particular attention with their integration into education (Ghuloum, 2010). Digital hologram was described as records created by the three-dimensional interference of laser light waves (Jampala & Shivnani, 2014). The concept of digital hologram is also defined as mediators that can bring 3-D images of certain objects to different settings and ensure the continuity of the image even in the absence of these objects (Katsioloudis & Jones, 2018).

Digital holograms, which have been used in the fields such as medicine, art, tourism, manufacturing industry and entertainment, were recently entered into the agenda with their use in education and they are intended to be included in education considering their advantages (Harper, 2010). In this sense, the advantages of the use of digital holograms in education can be listed as providing realistic images to users, communicating through virtual images among people in different locations, allowing the inclusion of non-alive characters into the real world through digital holograms (Kalansooriya et al., 2015). In addition, it is known that the use of digital holograms in education has other advantages such as contributing to the education industry on a large scale, structuring future knowledge, and providing industrial development in education with innovative technologies (Mavrikios et al., 2019). When all these advantages are taken into consideration, the use of digital holograms in education came into question, especially in science education, which is thought to be easier to integrate technology (Khurmyet, 2016).

In science, it is predicted that the use of digital holograms, which enables us to obtain three-dimensional images, will be appropriate in the concretization of the abstract topics in science, such as microscopic creatures, extinct creatures, systems in our body, the nature and particulate structure of matter, biodiversity, cells and divisions, reproduction growth and development of living creatures (Seckin Kapucu, 2020). In this way, students were assumed to be able to better envision these abstract concepts that they hear in the class. In this sense, using hologram technology in the class is thought to make the topics recallable and provide fast learning opportunities for students (Aslan & Erdogan, 2017). Moreover, the use of digital holograms in the instruction of the topics covered in the science curriculum may offer students meaningful learning opportunities and digital holograms may increase the motivation of the students (Orcos & Magrenan, 2018). In addition, there are studies in the literature reporting that the use of digital holograms in education has direct effects such as facilitating learning, contributing to students' visualization and retention skills, being a technological teaching tool that can be easily used in classroom setting, and adaptation to future technology (Roslan & Ahmad, 2017; Sudeep, 2013).

Regarding the literature; Orcos and Magrenan (2018) investigated the effect of instructing cell division topic with digital holograms on meaningful learning. As a result of the research, the satisfaction levels of the students towards holograms were found to be high. It was also concluded at the end of the research that digital holograms can be a motivational teaching tool. Sudeep (2013) investigated the significance of digital holograms in learning settings. As a result of the study, it was concluded that digital holograms can be an effective teaching tool for the future. Okulu and Unver (2016) aimed to support teacher candidates' thinking and problem-solving skills with holograms. As a result of the research, teacher candidates' astronomy knowledge was observed to increase with the products created by themselves in astronomy. In their study, Aslan and Erdogan (2017) talked about the necessities of using technology in education. They emphasized that with technologies such as hologram, topics can be more memorable for students and students can be provided with fast learning.

Regarding all this information, it can be said that digital holograms can be used in classroom settings and this innovative technology can be preferred as a teaching tool. At the same time, it is thought that digital holograms will make abstract concepts, especially the ones included in science education, easy to express and facilitate to explain the topics that are difficult to understand (Turk, 2020). In addition, with digital holograms it is expected that the shortcomings in science education, such as the provision of microscope, telescope, can be eliminated and students will be able to see the contents of the topics they want to examine, such as cell, solar system and planets, etc. in three-dimensions (Seckin Kapucu, 2020). Moreover, it is thought that the images obtained with digital holograms will allow the students to experience the feeling of reality and, accordingly, students can get real life experiences (Kalansooriya et al., 2015).

The review of the literature shows that the technologies used in science education usually contain similar activities and materials. Research on the integration of digital holograms into education, especially into science education and students' attitudes on this issue are rare (Cabı, 2016; Huffstetter et al., 2010). Hence forth, with this study, it is thought that the use of digital hologram applications, which is quite rare in science education, will be promoted, and thus, the relationship between science and technology will be strengthened, digital holograms will be integrated into science classes and science education-technology integration will be addressed from a different perspective. Accordingly, this study aimed to examine student attitudes, thoughts, suggestions and opinions about the use of digital holograms in science class. For this purpose, the following sub-objectives were addressed.

- Is the digital hologram attitude scale used to measure students' attitudes towards digital hologram a valid and reliable scale?
- Is there a significant difference between the attitudes of students towards digital hologram, which is one of the innovative technologies, according to gender, grade, school and science course academic achievement score?
- What are the student opinions regarding the use of digital hologram in science class?

Methodology

Research Model

In order to determine the attitudes of secondary school students towards digital hologram, which is one of the innovative technologies, sequential explanatory approach model, which is a combination of quantitative and qualitative methods, was used in this study. The reason for choosing a mixed research pattern for the study is to ensure that the problem status is explained and interpreted in the best way using quantitative and qualitative data together, to reach strong evidences supporting each other and to perform an in-depth analysis with richer results (Rossman & Wilson, 1994). In the analysis process of sequential explanatory approach model, which is one of the mixed research designs, quantitative data was analyzed first, then the two data groups were combined and interpreted together, and the comments were discussed in the discussion section (Creswell & Clark, 2017).

Study Group

The study was carried out with a total of 418 students, 228 girls and 190 boys, from 5, 6, 7 and 8th grades, who were attending 6 different state secondary schools affiliated to the Provincial Directorate of National Education in the Aegean Region, during the fall semester of 2018-2019 academic year. Maximum diversity sampling method, which is one of the purposeful sampling methods, was used. Accordingly, the study group has been diversified according to gender, grade, school and academic achievement score variables. The demographic characteristics of the study group are shown in Table 1.

Table 1.Demographic characteristics of the study group

Variables		*f*	%
Gender	Female	228	54.55
	Male	190	45.45
School	School 1	105	25.11
	School 2	90	21.53
	School 3	83	19.85
	School 4	65	15.55
	School 5	38	9.10
	School 6	37	8,86
Grade	5th grade	123	29.42
	6thgrade	105	25.11
	7th grade	120	28.70
	8th grade	70	16.77

f = frequency

Regarding Table 1, 54.55% of the students constituting the study group were female and 45.45% were male. In addition, 25.11% of the students participating in the study were from school 1, 21.53% from school 2, 19.85% from school 3, 15.55% from school 4, 9.10% from school 5 and 8.86% from school 6. 29.42% of the students participating in the study were from 5th grade, 25.11% from 6th grade, 28.70% from 7th grade and 16.77% of them were from 8th grade.

Research Process

Science topics, in which digital holograms will be employed during the research process, have been determined before the process based on the gains in the science curriculum. First researcher prepared digital hologram videos on the topics specified for 5th, 6th, 7th and 8th grades. The topics specified were as follows: 5th grade, “extinct creatures” from the “biodiversity” topic of “human and the environment” unit; 6th grade, “structures and organs” included in the “support movement system, digestive system, and circulatory system” topic of “the systems in our body” unit; 7th grade, “comparison of animal and plant cells” from the “cell” topic of “cells and divisions” unit; 8th grade “the helix structure of DNA, gene and chromosomes” from “The structure and self-mapping of DNA” topic of “DNA and genetic code” unit. During the application process, 24 hologram videos prepared by the first researcher were used. Hologram videos prepared on the topics determined for each grade were presented to the students of the relevant grade. During the application process, the topics were instructed by the teacher of the course and supported by digital hologram videos prepared by the researcher. Hologram pyramids required for the use of digital hologram videos are designed by the students in the classroom. Students were given a ten-minute period in the lesson to design the hologram pyramids. During this period, the operation was smoothly processed by providing students with the information about the steps of hologram pyramid preparation. Then, hologram images on related topics were examined using the hologram pyramids prepared by the students. Digital hologram images used in the application process are shown in Figure 1-2-3-4.

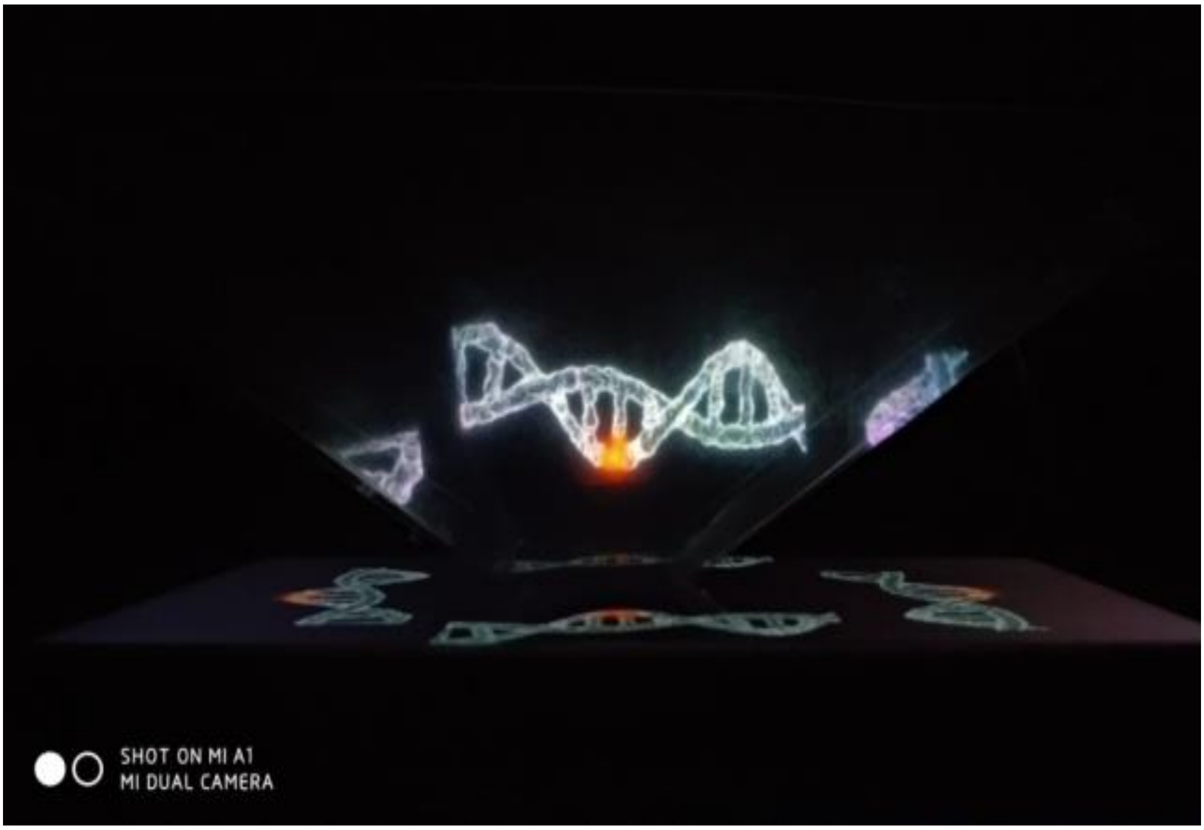

Figure 1. The Helix Structure of DNA

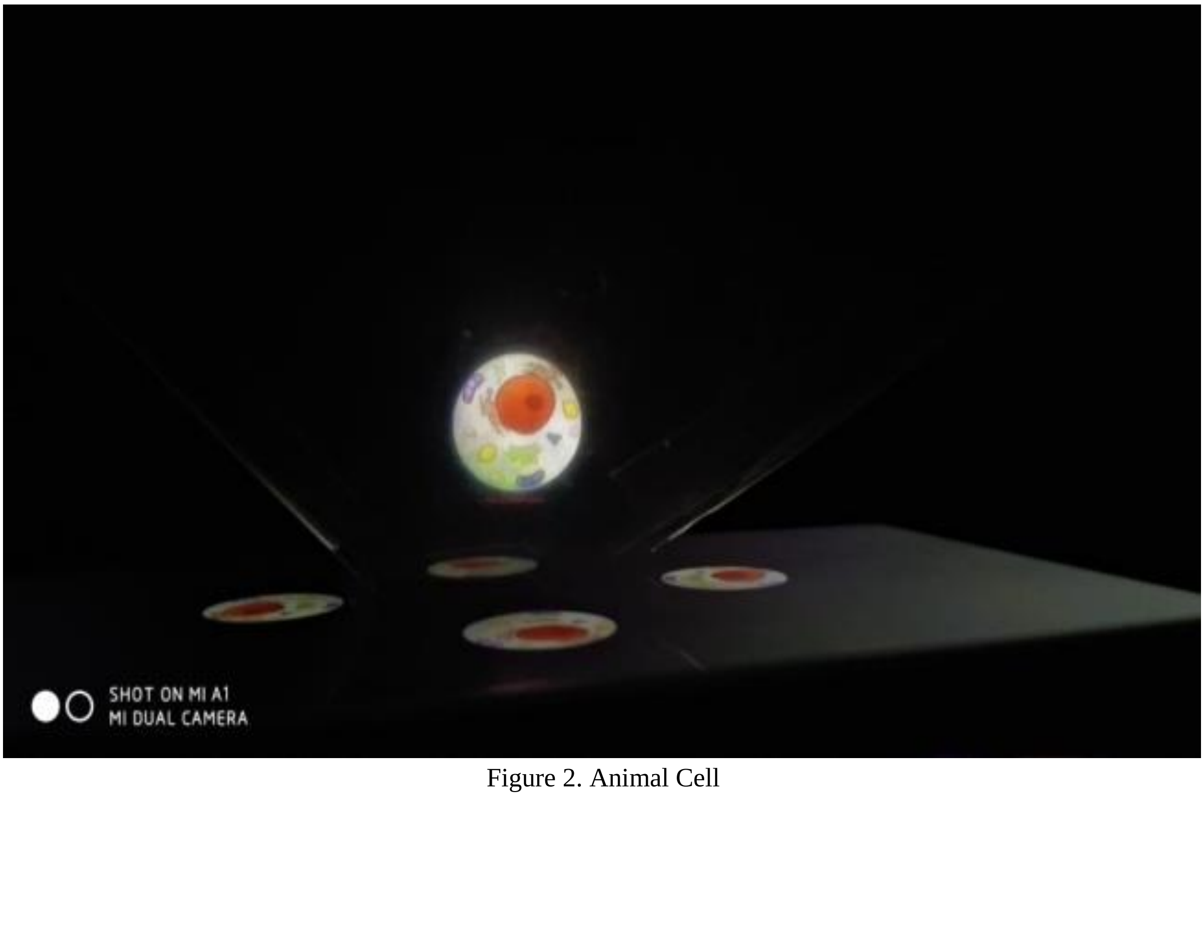

Figure 2. Animal Cell

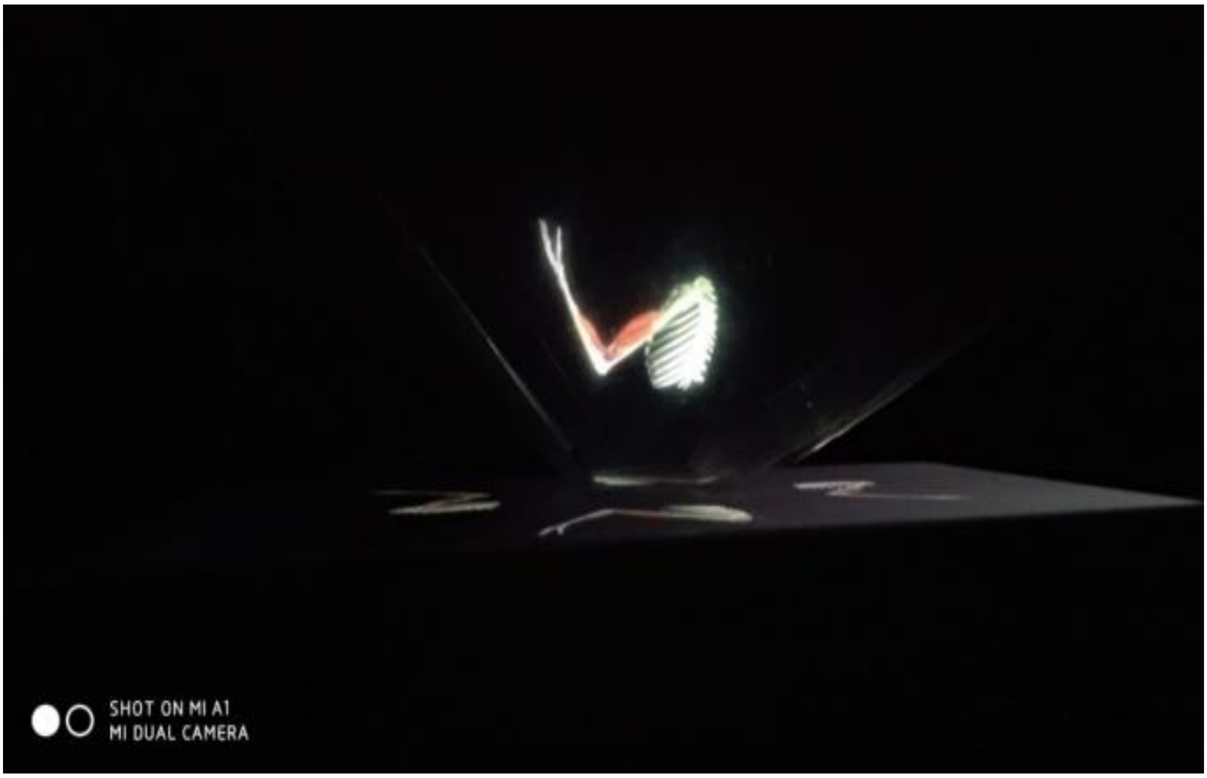

Figure3. Support and Movement System

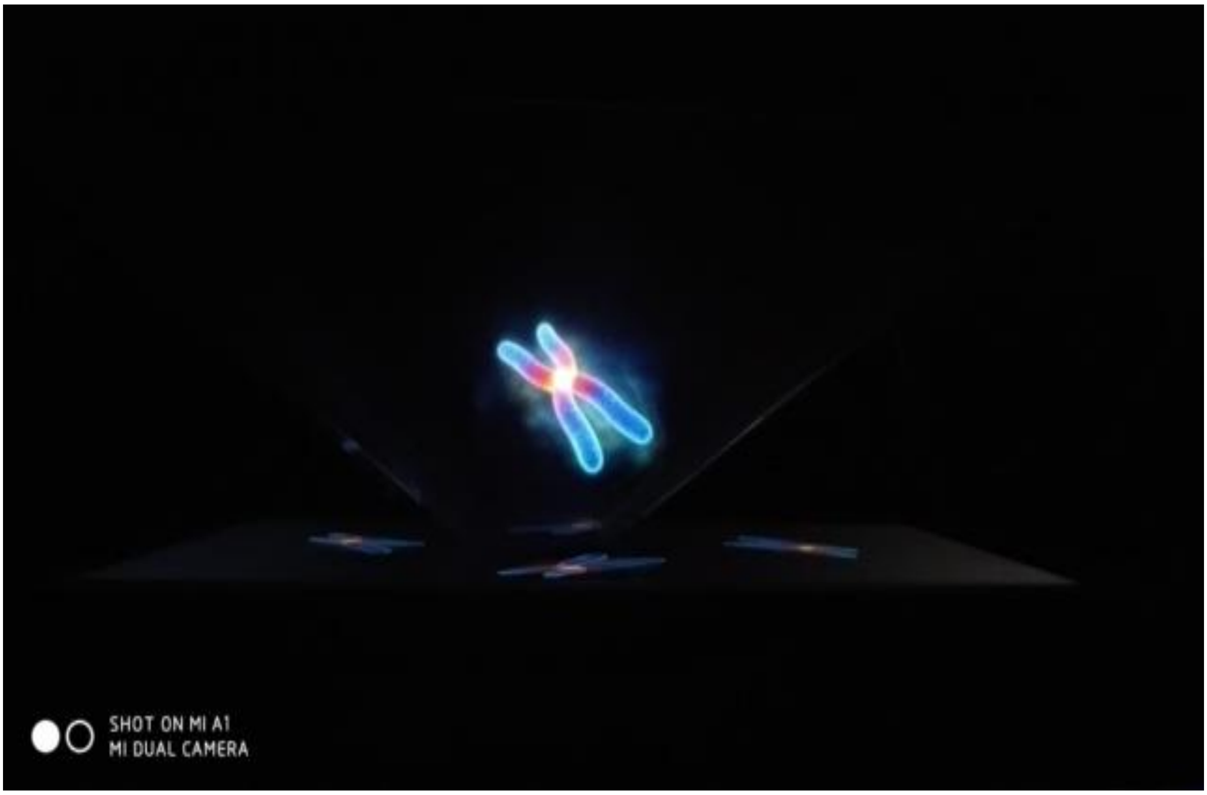

Figure 4. Chromosome

Data Collection Tools

Digital Hologram Attitude Scale (DHAS) developed by researchers was employed in the study to determine students' attitudes towards digital hologram. In order to determine students' thoughts, suggestions and opinions about digital hologram, Digital Hologram Reflection Form (DHRF) prepared by the researchers was used.

Digital Hologram Attitude Scale (DHAS)

In the first stage of the scale development process, the relevant national and international literature was reviewed. In addition, the previous scale development studies on the attitude towards technology, the use of digital holograms in education and the gains included in the science curriculum were reviewed. As a result of the review, the items that represent the attitudes towards digital hologram were specified and a pool of items was created with the statements that will measure these items. In the second stage of the scale development process, item pool, scale format and answering options were created. DHAS consists of two parts. The first part of the measurement tool includes students' personal information, gender, grade, school, and science course academic achievement score.

The second part is comprised of 28 scale items with 5-point Likert structure, created to determine students' attitudes towards digital hologram. Regarding the study group, using a Likert type scale was considered to be appropriate in terms of applicability and usefulness. The scale was arranged as 5-point Likert scale and the items included in the scale were scored as; 1 = “Strongly Disagree”, 2 = “Disagree”, 3 = “Neither Agree / Disagree”, 4 = “Agree” and 5 = “Strongly Agree”. Five levels were specified, where the lowest scores obtained from the scale was “1.00” and the highest “5.00” (Edwards, 1983; Seker & Gencdogan, 2014). Deciding on the format of the scale, expert opinion was consulted. A science education specialist, an information technology specialist, a science teacher and a measurement and evaluation specialist reviewed the items in the scale. Following expert opinions, necessary arrangements were made in the scale items. Exploratory factor analysis (EFA) was performed on the data obtained from DHAS in order to determine the factor structure and provide evidence for structural validity. Confirmatory factor analysis (CFA) was performed using LISREL 8.51 software to confirm the accuracy of the factor structure obtained from EFA. Cronbach's alpha internal consistency coefficient was calculated to provide evidence for the reliability of the entire scale.

Digital Hologram Reflection Form (DHRF)

DHRF prepared by researchers was used to collect qualitative data of the study. DHRF consists of two parts. The first part of the reflection form includes students' personal information, gender, and grade, whereas the second part consists of 7 open-ended questions prepared considering the purpose of the research, investigating students’ thoughts, suggestions and opinions about hologram applications. The prepared reflection form got ready to apply upon taking the opinions of a science education specialist, an information technologies specialist and a measurement and evaluation specialist.

Data Collection Process

Data collection process was completed in 5 weeks. In the first three weeks of the data collection process, the topics determined for each grade were instructed by the teacher and supported by digital hologram videos prepared by the researcher. In this process, hologram pyramids used to watch hologram videos were prepared by students. The instruction of the topic was supported with hologram pyramids and hologram videos prepared by the researcher for related topics. In the fourth and fifth weeks of the process, quantitative data was collected by administering DHAS on the students.

After the quantitative data were collected, three achievement groups were formed according to the science course academic achievement score for each grade, namely 5th, 6th, 7th and 8th grades. The achievement groups were based on 100-point system used by the Ministry of National Education. Students were grouped according to science course achievement score as: 85-100, 70-84.99, 55-69.99, 45-54.99 and 0-44.99. Then, students having a score between 84.99 and 100 were classified as successful, 55-69.99 as mediocre and 0-54.99 as unsuccessful. The purpose of this process is to reach students' opinions from each grade and achievement level and reflect maximum diversity in the sample. The same procedures were repeated for each grade, 4 students from 3 achievement groups of each grade were specified, and then DHRF was administered on a total of 48 students to collect the qualitative data.

Data Analysis

SPSS 22.0 and LISREL 8.51 softwares were used in the analysis of quantitative data obtained from DHAS. Data was entered into the program and was cleared. The normal distribution of the data was tested.

Table 2. Descriptive statistics of the items and factors

Items and factors		$\bar{X}$	df	Item total cor.
Factor 1-Intrinsic motivation				
I4	The topic of science course in which digital hologram activities are used attract my attention.	3.54	0.03	0.50
I2	I wonder how digital hologram activities will end.	3.25	0.02	0.57
I5	Using digital hologram activities in class increases my interest towards the course.	3.72	1.23	0.62
I3	Using digital hologram activities in class increases my curiosity towards the course.	4.01	0.04	0.46
I6	In order to design the digital hologram myself, it is enough to see it once.	2.19	0.03	0.71
Factor 2- Facilitating learning				
I27	I may not be able to learn every concept in the science class with a hologram.	2.68	1.14	0.30
I28	I can use digital holograms whenever I want.	2.03	1.26	0.29
I26	It is easy to learn new concepts with digital holograms.	2.59	1.33	0.32
Factor 3- Continuity of learning				
I8	Digital hologram activities help me discover new knowledge.	2.52	1.05	0.43
I7	I can make research about the usage areas of digital hologram activities.	2.28	1.07	0.35
I9	The design process of the digital hologram draws my attention.	2.09	0.04	0.66
Factor 4- Technological motivation				
I14	It is fun to create images with digital holograms.	3.45	1.01	0.59
I13	Being in touch with technology in the courses gives me pleasure.	3.17	0.03	0.46
I15	Making digital holograms in the classroom excites me.	2.36	0.02	0.54
Factor 5- Real life experiences				
I19	I can produce solutions for different problems with digital hologram activities.	2.77	1.04	0.58
I11	I like the image formed in digital hologram applications to be in vivid colors.	2.15	0.02	0.71
I10	I can understand what the image formed in digital holograms is.	2.68	0.03	0.67
I20	I may need help if I want to use digital hologram applications in a course other than science.	1.02	1.20	0.33
Factor 6- Technological proficiency				
I16	I believe that I can easily learn the challenging topics with digital hologram applications.	4.01	1.06	0.23
I12	I can teach digital hologram application to others.	2.04	1.12	0.37
I18	I can perform digital hologram activities I learned alone.	1.96	1.11	0.44
Factor 7- Diversity of use				
I24	Digital hologram applications make me think of imaginary concepts as real.	3.99	1.19	0.65
I25	I'm curious about the next digital hologram activity.	3.20	1.27	0.64
I21	I know that digital hologram applications are used in different fields.	2.72	0.02	0.74
Factor 8- Physical properties of hologram				
I23	Colorful holograms increase my interest towards the activity.	2.08	1.08	0.59
I22	I can easily find the materials used in digital hologram design.	2.95	0.03	0.63
Factor 9- Keeping up with the developments				
I17	I am pleased to learn new information through digital hologram applications.	3.09	1.09	0.40
I1	I follow scientific developments about digital hologram applications.	4.18	0.03	0.72

$\bar{X}$ *=arithmetic mean*
df =degree of freedom

In order to determine the reliability and validity of DHAS, factor analyzes was performed and Cronbach alpha coefficients representing item-scale correlation were calculated. EFA and CFA factor analyzes were used in analyzing the data and the dimensions of the scale were specified. At the same time, items to be included in the scale were determined by correlation-based item analysis. In addition, the average score of each item in DHAS was calculated. Regarding the evaluation of the arithmetic means of the items included in the attitude scale, the range intervals were determined as 4/5 = 0.80 by using the formula of "Range Width = (Sequence Width)/(Number of Groups to be Made)". Hence, 1.00-1.79 range corresponds to “Strongly Disagree”, 1.80-2.59 “Disagree”, 2.60-3.39 “Neither Agree/Disagree”, 3.40-4.19 “Agree”, and 4.20-5.00 to “Strongly Agree” (Tekin, 1996).

Afterwards, negative items were reverse coded, the average scores of students' attitudes towards digital hologram was calculated and students' attitudes were interpreted according to the corresponding score range. At the same time, independent samples t-test was used to compare students' attitudes towards digital hologram according to gender, and one-way analysis of variance (ANOVA) was used in performing three and more group comparisons in terms of academic achievement score. Levene test was used to test the homogeneity of the variances before the analyzes. Levene test’s result was over 0.05, therefore the variances were assumed to be homogeneous and LSD test, which is one of the common post-hoc multiple comparison tests, was preferred to determine the source of the significant difference in the multiple comparison of average scores (Buyukozturk, 2013).

Content analysis was employed to analyze the qualitative data collected by DHRF. The main purpose of content analysis is to reach the information related to the concepts that can explain the collected data. In this study, qualitative data was analyzed in four stages: coding data, creating themes, organizing codes and themes, and identifying and interpreting the findings (Yıldırım & Simsek, 2008). In the qualitative analysis, DHRF data were transcripted first. All qualitative data was reviewed by the researcher. The responses of the students participating in the research were coded by thematic coding and content analysis tables were created. In order to support the themes and codes created by content analysis with examples, quotations from student opinions were included. Students' opinions on digital holograms were analyzed by two researchers, then inter-coder reliability was checked. Cohen Kappa's correlation coefficient between the coders was calculated using the formula (KAG) = Agreement / (Agreement + Disagreement) on the total scores obtained from the evaluations of both researchers (Miles & Huberman, 1994). Cohen Kappa's correlation coefficient was approximately $\kappa = .75$, which indicates a good consistency between raters. Cohen Kappa coefficient between 60 and 70 is an indication that the correlation coefficient between the raters/observers is good (Sencan, 2005).

Results

This section includes the findings obtained in line with the objective and sub-objectives of the research. The results of the findings obtained from DHAS within the scope of the study are shown. The items grouped under each factor, factor names and descriptive statistics of the factor items are shown in Table 2. Regarding Table 2, the item total correlations of DHAS items vary between 0.23 and 0.74. Cronbach alpha coefficients were calculated in order to provide evidence for the reliability of 28 items included in DHAS. Cronbach alpha coefficient of the whole scale was found to be 0.96. The reliability coefficients of DHAS factors are shown in Table 3.

Table 3.Reliability coefficient of DHAS and its factors

Factors	Number of items	Cronbach alpha
Intrinsic motivation	5	0.95
Facilitating learning	3	0.85
Continuity of learning	3	0.89
Technological motivation	3	0.90
Real life experiences	4	0.85
Technological proficiency	3	0.78
Diversity of use	3	0.80
Physical property	2	0.80
Keeping up with the developments	2	0.85
Overall	28	0.96

Regarding Table 3, the reliability coefficients of the factors were found to be as follows: Intrinsic motivation – 0.95, Facilitating learning - 0.85, Continuity of learning – 0.89, Technological motivation – 0.90, Real life experiences – 0.85, Technological proficiency – 0.78, Diversity of use – 0.80, Physical property – 0.80, and Keeping up with the developments – 0.85. The reliability coefficients obtained for each factor are 0.70 and above, which is an indicator of the reliability of the scale; hence the reliability coefficients being between 0.80-1.00 is seen as an indicator of the high reliability of the scale (Buyukozturk, 2013; Kalayci, 2005).

The factor structure of DHAS was tested by confirmatory factor analysis, which tests of the compatibility of the factor structure formed by EFA with the data (Tabachnick & Fidell, 2007). CFA was performed using LISREL 8.51 software to verify the nine-factor structure obtained by EFA and fit statistics were calculated for the nine-factor model. Regarding the fit indices of the model that is subjected to confirmatory factor analysis, chi-square value (X^2 = 416.78, N = 418, df = 314, p <0.05) was observed to be significant. However, since the probability of significant analysis results increases as the sample size increases, it is recommended to check X^2/df ratio for large samples; the ratios lesser than five are accepted as an indicator of compliance (Kline, 1998; Sumer, 2000). The fit index values of the scale for CFA are shown in Table 4. Regarding Table 4, the value obtained by dividing the chi-square fit index to the degree of freedom was found to be 1.3273, which is smaller than 3, indicating a perfect fit (Kline, 1998; Sumer, 2000). In addition, comparative fit index (CFI) was found to be 0.95 indicating a perfect fit, and goodness of fit index (GFI) was found to be 0.93, indicating a good fit (Hu & Bentler, 1999; Schumacker & Lomax, 2010). At the same time, The Root Mean Square Error of Approximation (RMSEA), which is 0.028, indicates a perfect fit (RMR), which is 0.036 indicates a good fit (SRMR), which is 0.047, indicates a perfect fit (Brown, 2006; Hu & Bentler, 1999).

Table 4. CFA fit indexes for DHAS

Fit indicators	Achieved values	Acceptable values
X^2/df	1.3273	$2\leq X^2/df\leq 3$ (Kline, 1998; Sumer 2000)
CFI	0.95	0.95≤CFI≤0.97 (Hu & Bentler,1999)
GFI	0.93	0.90≤GFI≤0.95 (Schumacker & Lomax, 2010)
RMR	0.036	RMR<0.08 (Hu & Bentler, 1999)
SRMR	0.047	0.05<SRMR<0.10 (Brown, 2006)
RMSEA	0.028	0.00<RMSEA<0.05 (Hu & Bentler, 1999)

X^2/df = chi-square/degree of freedom

Findings of the analysis of students' attitudes towards digital hologram according to several variables

Descriptive tests were used to discover students' attitudes towards digital hologram. The average of the scores that students got from DHAS was found to be 78.05 and the standard deviation was 13.06. The average of their attitude towards digital hologram corresponds to 3.46 at the Likert-type scale. Accordingly, the average is within the range of 3.40-4.19, corresponding to the expression "I agree" and it can be said that students' attitudes towards digital hologram are generally positive (Tekin, 1996).

Independent groups t-test was used to determine the differentiation of students' attitudes towards digital hologram according to gender. Regarding t-test results, the average score of female students was $\bar{X}$= 80.63 and male students was $\bar{X}$= 75.35. But, the difference of students' attitudes towards digital hologram was found to be insignificant according to gender (p> 0.05). ANOVA test results shows, the attitude of the students towards digital hologram were observed not to differ significantly according to grade ($F_{(3.414)}$=1.141; p>0.05). The findings are shown in Table 5.

Table 5.ANOVA test results of students' DHAS scores according to grade

Source of the variance	Sum of squares	df	Average of squares	F	p
Inter-groups	529.242	3	176.414	1.141	.236
Intra-groups	64028.365	414	154.657		
Total	64557.607	417			

df =degree of freedom   F =comparison of variances   p =significance

Independent samples single factor ANOVA was used to determine the differentiation of students' attitudes towards digital hologram according to the school they attend. The findings of the ANOVA test performed are shown in Table 6.

Table 6.ANOVA test results of students' DHAS scores according to school

Source of the variance	Sum of squares	df	Average of squares	F	p
Inter-groups	1432.849	5	286.569	1.796	.089
Intra-groups	65748.793	412	159.584		
Total	67181.642	417			

Regarding ANOVA test results in Table 6, the attitude of the students towards digital hologram were observed not to differ significantly according to school ($F_{(5.412)}$=1.796; $p>0.05$). Independent samples single factor ANOVA was used to determine the differentiation of students' attitudes towards digital hologram according to science course academic achievement score. The findings are shown in Table 7.

Table 7.ANOVA test results of students' DHAS scores according to science course academic achievement score

Source of the variance	Sum of squares	df	Average of squares	F	p
Inter-groups	2578.674	4	644.668	3.829	.016
Intra-groups	69372.416	412	168.379		
Total	71951.090	416			

Regarding Table 7, the scores from DHAS were observed to differentiate significantly according to students' science course academic achievement score ($F_{(4.412)}$=3.829; $p<0.05$). Hence, Levene test was performed to check the homogeneity of the variance. Levene test result was 0.86> 0.05, therefore the variances were assumed to be homogeneous, then LSD test was applied in order to specify the groups between which the difference was observed, and the findings are shown in Table 8.

Table 8. LSD test results applied to students' DHAS scores according to science academic achievement score

Comparison of the groups	p	Significant Difference
Excellent-unsuccessful	.04	Excellent > unsuccessful Excellent > mediocre
Excellent -mediocre	.02	
Excellent -good	.36	
Mediocre- unsuccessful	.71	
Good- unsuccessful	.54	
Pass- excellent	.069	

p =significance

Regarding Table 8, the significant difference in academic achievement score among the groups was found to be in favor of students with an excellent science course academic achievement score (85-100). Accordingly, it can be said that the attitude of the students with excellent academic achievement scores towards digital hologram is higher than unsuccessful (0-44.99) and mediocre (55-69.99) students.

Findings about students' opinions on the use of digital hologram in Science course

Students', thoughts, suggestions and opinions about digital holograms was collected via DHRF prepared by the researcher. There are seven open-ended questions in the reflection form. DHRF was applied to 48 students in total, 4 students in each of the 3 success groups determined for each grade. All qualitative data was reviewed by the researcher. Content analysis tables were created by coding the responses of the students participating in the research by thematic coding method. To support the themes and codes created by content analysis with examples, quotations from student opinions were included. Codes such as P1, P2, P3 were assigned to each participant while quoting statements. The themes, categories, codes and frequencies about the use of digital holograms in science class are shown in Table 9.

The answers given by students regarding the use of digital holograms in science class were grouped under three themes as thoughts, practices and suggestions (Table 9). The categories under the theme of thoughts are "hologram applications" and "technological applications in science class".

Table 9.Themes, categories, codes and frequencies about the use of digital holograms in science class

Themes	Categories	Codes	*f*
Thoughts	Hologram applications	Useful	9
		Real-like	7
		Impressive	5
		Funny	5
		Motivating	4
		Interesting	4
		Striking	3
		Instructive	2
		Scientific	1
		Thinking tangibly	1
		Exciting	1
		Intriguing	1
		Convenient	1
	Technological applications in science class	Facilitating learning	14
		Facilitating understanding	11
		Making lessons fun	8
		Supporting academic achievement	4
		Creating lifelike setting	1
Practices	Previous usage	No/ I didn't use	30
		Yes/I used	6
	Impact on Learning	Academic learning	22
		Learning with fun	11
		Academic motivation	7
		Active participation	2
		Cooperative learning	1
Suggestions	Topics	Solar system and planets	9
		Space researches	8
		Living creatures	6
		Particulate structure of matter	4
		Systems in our body	2
		Electricity	2
		Periodic system	2
		Cycles of matter	1
		Seasons	1
		Nature events	1
	Other courses	All courses	16
		Mathematics	11
		Social Sciences	5
		Only Science	3
		Information technologies	2
		English	2

f = frequency

The code mostly mentioned in the category of hologram applications is "useful". Accordingly, it can be said that students find the hologram applications useful. A participant on this issue said, "Science lessons with holograms were really good. It should be used because better, useful lessons are instructed with holograms (P3)", another opinion supporting this was, "I found the hologram applications good. I think it will also be useful for my lessons and my future (P7)". Another frequently mentioned code of hologram applications category is the real-like. A participant regarding the holograms being real-like said, "It is very realistic. What we see in the hologram is retained and what we want to examine can be examined in more detail thanks to the holograms (P15)", whereas another participant supported this opinion as, "I think Hologram application is very realistic, so people will learn 3-D things like real (P29)". Another category under the theme of thoughts is technological applications in science class. The codes included under this category are facilitating learning, facilitating understanding, making lessons fun, supporting academic achievement, and creating lifelike setting. The most frequently mentioned code of the category is “facilitating learning”. Accordingly, it can be said that the students mostly evaluate the use of technological applications in science course as providing convenience in learning. A participant expressed her opinion on this issue as, “If hologram application is used in science class, it will be better for me because I understand better with images. I can learn the topics easily (P38)”, whereas another participant said, “I think the use of technology in science class is very positive, it would be nice if we use it from now on, it could make it easier for us to learn the lessons (P6).”

The practices theme includes “previous usage” and “impact on learning” categories. Previous usage category consists of the codes “No/ I didn’t use” and “Yes/I used”, where “No/I didn’t use” is the mostly mentioned code. A participant said on this issue, “I have not use it before. But I liked it very much and will use it from now on (P13)”, another one expressed his opinion as, “I have never used them before but from now on if I don’t understand a topic, I will try to understand it by making holograms (P32).” This code was followed by “Yes/I used”. A participant said, “Yes, I have used it before. We designed and built the hologram pyramids in a Tubitak project (P39)”, another participant's opinion was “I used it. A teacher has told about holograms and I was interested, then I watched the videos and made and used them at home (P28)”. Another category under the application theme is the impact on learning, which includes “Academic learning”, “Learning with fun”, “Academic motivation”, “Active participation” and “Cooperative learning” codes. The code mostly mentioned under this category is observed to be academic learning. A participant said, “I will understand the topics in science class better if holograms are used. I understand more easily with holograms because it is the course that I usually have difficulty in understanding. No question remains in my mind (P29)”, another opinion supporting this was “I usually understand better with shapes, pictures, including the questions. Since there are beautiful visuals in the holograms, I can say that they will contribute a lot to my learning (P33). ”

Suggestions theme includes the “topics” and “other courses” categories. The codes under the topics are: “Solar system and planets”, “Space researches”, “Living creatures”, “Particulate structure of matter”, “Systems in our body”, “Electricity”, “Periodic system”, “Cycles of matter”, “Seasons” and “Nature events”. The most mentioned code of this category is observed to be “Solar system and planets”. A participant said, “I would like it to be used on the sun and planets. I am both curious about it, and I think that with holograms I can see them in a colorful and radiant way and make observations (P12)”, whereas another participant's opinion was, “We can see the phases of the moon in motion with holograms. It will be notable. Seeing the light or dark sides of the moon at each stage. Holograms make the topic memorable (P21)”. The other category of suggestion theme is other courses, which includes “All courses”, “Mathematics”, “Social Sciences”, “Only Science”, “Information technologies” and “English” codes. The most mentioned code of other courses category is all courses. A participant expressed her opinion as “I’m in favor of the use of holograms in all courses, I think all courses are suitable for using holograms (P7)”, another participant said, “I think it would be nice in every class. The child, who understands only one lesson, will understand the others as well, the interest towards other courses will increase, the grades will improve, student will be better. Holograms can be used in any lesson (P34)”.

Discussion and Conclusion

In this study, it was aimed to analyze students' attitudes towards the use of digital hologram in the instruction of the topics in the science class and students' thoughts, suggestions and opinions about the use of digital holograms. For this purpose, data obtained from DHAS and DHRF developed by the researcher were analyzed. Quantitative data from DHAS were supported by qualitative data from the DHRF, ensuring consistent results.

In order to test the validity and reliability of DHAS developed by the researcher, content and structure validity, item total correlation, and Cronbach alpha internal consistency coefficient were calculated and the factor structure of the scale was tested with factor analysis and accordingly, it was confirmed that the model has an acceptable fit.

As a result of the study, according to the findings obtained from DHAS, it was concluded that students' attitudes towards digital hologram did not differ significantly by gender. Similarly, Bakr (2011) and Bush (1995) have not find a significant difference between attitudes towards technology and gender. At the same time, students' attitudes towards digital hologram did not show a significant difference according to grade. However, the attitude scores of 5^{th} grade students towards digital hologram were found to be higher than those of 6^{th}, 7^{th} and 8^{th} grade students. In addition, students' attitudes towards digital hologram were observed not to differ significantly according to schools they were attending. Students' digital hologram attitude scores differed significantly according science course academic achievement score. Regarding the findings obtained from the multiple comparison test performed to determine the source of this difference, it was concluded that the students with excellent achievement score had higher digital hologram attitude score than the students who were unsuccessful and mediocre. In the study of Birgin and Zengin (2016), a significant difference in students' attitudes towards technology was reported in favor of students whose course grade was between 85 and 100.

Students' thoughts, suggestions and opinions about digital hologram were reviewed via DHRF, and the findings obtained indicated that students had generally positive opinions about the use of technological applications in science class. At the same time, students evaluated the digital holograms as useful and realistic. Regarding the studies in the literature, it was concluded that digital holograms facilitate understanding and learning and contribute to students' learning by making fun. In addition, there are studies indicating that the use of digital technologies in the classroom setting makes the lessons interesting and contributes to students' understanding the course more easily (Arioglu & Uzun, 2008; Cagiltay et al., 2001). Moreover, the inclusion of technological equipment in classroom settings was considered to facilitate the education as the technology facilitates the daily life and meet the needs of education (Van Wyk & Louw, 2008). Students suggested that hologram applications can be used in the topics such as solar system and planets and space research of the science course. In addition, digital hologram applications can be used not only in science class but also in all other courses and especially in mathematics. This finding overlaps with the finding of Gul and Yesilyurt (2011), who reported that students wanted to use digital technologies as much as possible in the courses. In addition, the use of technology in the classroom setting was observed to offer a rich learning and teaching environment for both students and teachers (Delen & Bulut, 2011; Guzel, 2011).

Recommendations

In line with the results obtained from this study, the following suggestions can be submitted: It is recommended to include the use of technological equipment in the world of education and to benefit from the advantages provided by technology. At the same time, instead of computers, smart boards, simulations etc., which are frequently used in education, innovative technologies such as digital hologram, which have been mentioned recently and included in this study, can also be used and students can be given the opportunity to be in touch with these technologies. Accordingly, it is recommended that educators are informed about these technologies and studies should be carried out in order to use innovative educational technologies in the world of education and bring them to classroom settings. As a result of the research, students' opinions towards the digital hologram indicated that holograms can facilitate the understanding and learning of the lesson. Hence, innovative technologies such as digital hologram can be used in classroom settings instead of mockups and models used in the instruction. These technologies, which are carried to classroom settings, can expand students' perspectives on technology. In addition, it is recommended to use digital holograms that provide a sense of reality in science education for the concretization of abstract concepts, or in the fields such as space researches, solar systems, sky observations, which are considered to be impossible for students to observe in daily life.

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