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Research Article

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From science-fiction to reality: Developing research skills of secondary school students with film analysis methods

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ABSTRACT

The study, carried out as part of an eTwinning project, aims to develop eighth grade students' research skills using the film analysis method. The study also investigated the effect of the method on the astronomy interest and achievement of 8th grade middle school students. The students were shown Armageddon (1998), a science fiction movie, and were asked to research projects designed as solutions to extraterrestrial threats in real life. Students who reached the demonstration of autonomous rendezvous technology (DART) project through research were asked to prepare a presentation and to present it to their classmates. The study group consisted of students from five different provinces. The method of the research is a weak experimental design since the results of the activities carried out with the students within the scope of the experimental design are interpreted and there is no control group. As the data collection method of the study, a mixed method including both quantitative and qualitative data was determined. In order to collect quantitative data, "solar system and beyond achievement test" and "scale of interest in astronomy" were applied as pre- and post-test. In the qualitative part of the study, open-ended questions prepared by the researchers were used as data collection tools. As a result of the research, it was found that students' interest in astronomy changed and developed positively by watching and analyzing movies, brainstorming, creating a sense of curiosity, encouraging research and other activities within the scope of the eTwinning project.

Keywords: DART project, science-fiction films, science education, eTwinning

INTRODUCTION

Science begins with curiosity and interest. Curiosity is the greatest power that pushes people to investigate and discover the unknown (Hidi et al., 2004). From the past to the present, knowledge has been acquired through the systematic research process of curious people until they reach the result. Since the key to learning in education requires arousing students' curiosity, motivating students, and enabling their unique aspects to emerge, participating in school activities and making students' participation permanent is a determining factor (Elliott & Dweck, 1988; İnan Kaya, 2016; Ryan & Deci, 2000). Students' interests and curiosity, which have an important place in learning new concepts in science education, enable them to explore their surroundings by developing their imagination (Akimkhanova et al., 2023; Saraçoğlu & Kahyaoğlu, 2018). Astronomy is used as a tool to enable the new generation to understand science and to encourage them to engineering studies through scientific methods (Percy, 1998; Timur et al., 2020).

Astronomy is one of the most widely observed and researched branches of science due to its mysteriousness and curiosity about space (Ampartzaki et al., 2024; Taner et al., 2017). Observation and experimentation are directly related to the rate of development of technology (Chen et al., 2024). With Galileo, who expanded the knowledge of humanity in the field of astronomy and started the development of the telescope, the discovery of space objects invisible to the naked eye and the complexity of the sky came to the surface (Dreyer, 1953). In the 20th century, with the development of space technologies and the use of radio telescopes and space rockets, the limits of the wavelengths of visible space extended to the information obtained from the far corners of the universe and increased knowledge accumulation and carried the curiosities in astronomy to different fields (Unat, 2003).

The extinction of the dinosaurs 65 million years ago, which were the rulers of the earth before humans, is one of the events that have been a mystery and a curiosity from past to present. The most widely accepted of the theories developed to explain this situation is the impact of an asteroid named "Theia" on earth (Alvarez, 1983). Thousands of large and small asteroids

enter the earth's atmosphere every year. The vast majority of them burn up with the effect of air friction before reaching the earth's surface. But some of them hit the earth's surface. On the 13th of February 2023, at 02.59 UTC at night, the asteroid 2023 CX1, 1 meter in diameter, hit the English channel off the coast of Northern France. The impact information of CX1 was prepared with the notifications of the "Meerkat" warning system designed by ESA's (2023) Planetary Defense Office, and the use of a network of optical telescopes made this event history. In addition, thanks to the announcements made on social media, citizens from neighboring countries were able to record this event. CX1 does not pose a threat due to its size and impact location. However, one day, a meteorite with a diameter of not one meter, but perhaps 100 km, could threaten life on earth. For this reason, the movements of space objects outside the earth are carefully analyzed. Today, serious steps are being taken to protect our planet, with NASA's demonstration of autonomous rendezvous technology (DART) mission demonstrating that it is possible and ESA's (2022b) HERA mission.

DART Project

Since the 1960s, many studies have been carried out on space. Within 24 hours, the DART project, which aims to provide autonomous rendezvous with the targeted object in space and deviate the target from its course, aims to develop the necessary hardware and software (Rumford, 2003). The DART mission was carried out in 2005 and was partially successful. The advanced video guidance sensor was used to measure the rate of approach to the target. In this way, the theory that autonomous rendezvous with the target in space could be realized was supported (Howard & Bryan, 2007).

NASA's Planetary Defense Coordination Office has initiated a project to address and find solutions to the asteroid impact hazard. In the world's first asteroid deflection test, HERA planned to conduct a detailed investigation of what happens after the impact of the target asteroid Dimorphos, a Moonlet orbiting in a binary asteroid system known as Didymos. In the project, an asteroid system that would not pose any danger to the earth before and after the impact was chosen as the target for the test. The experiment called the asteroid impact deflection assessment (AIDA), is also the first experiment to demonstrate the reduction of asteroid impact hazard using a kinetic impactor (Stickle et al., 2016). AIDA, DART, and the ESA (2022a) asteroid impact mission are joint ESA-NASA projects. The first leg of the project, AIDA, was realized. On 26 September 2022, the binary asteroid system reached Dimorphos, the moon of Didymos, and completed its mission. The data received after the experiment and the verification of the impact models were documented and shared.

The probe on the secondary body of the Didymos binary asteroid system was used to visualize the impact effects. The LICIACube, launched from the rear of the double asteroid redirection test spacecraft, separated near the target and autonomously collided with the asteroid in the binary Didymos system in the last part of the mission and started collecting images of the asteroid (Michel et al., 2020).

In addition to the energy from the spacecraft, the eruption from the impact accelerated Dimorphos and aimed to change its orbit around Didymos. The main objective of the mission is to change the orbital period by 73 s. The change in orbit led to the measurement of the beta parameter and an increase in momentum (Moskovitz et al., 2022). Thanks to the DART mission, it was learned how to reduce the impact of the asteroid.

LICIACube provided the characterization of the velocity distribution versus the mass of the ejecta, which complemented the measurements of the DART impact criterion thanks to its dependence on the targeted power and porosity properties. In 2026, HERA arrived at Didymos to measure the crater radius and crater volume (Cheng et al., 2021). This will help to understand the DART effect along with the mass (m) - velocity distribution with ejection.

Before the impact of DART, the orbit of Dimorphos around the parent asteroid Didymos was calculated to be 11 hours 55 minutes. Since the autonomous collision of DART with Dimorphos, astronomers have used telescopes on earth to measure how much time has changed. Accordingly, it was confirmed that Dimorphos' orbit changed by 32 minutes with a margin of error of ±2 minutes. It was seen that the data, which was initially defined as a 73 s change, exceeded more than 25 times (Cheng et al., 2022).

The research team is still collecting data from laboratories and radars around the world and updating its observations. The new goal of the study appears to have shifted from a roughly 14,000 miles per hour (22,530 kilometers) collision with DART's target to measuring the efficiency of momentum transfer. This includes a more detailed analysis of the tons of asteroid rocks (ejecta) displaced by the impact and ejected into space. The rebound from this collision significantly increased the thrust of DART against Dimorphos.

The European Space Agency's HERA project is expected to carry out detailed surveys of both Dimorphos and Didymos over the next 4 years, focusing on the crater left by DART's impact and precise measurement of Dimorphos' mass (NASA, 2022). The DART Team continues to work on the rich data set to fully understand this first planetary defense test of asteroid deflection.

People's curiosity to understand space is one of the factors that shape the film industry. For this reason, many space-themed films have been shot. Although these films are fiction, they are called science fiction because they are based on current scientific developments (Tatlı & Şahin, 2020). Koeberl (1995), in an issue of Geochimica et Cosmochimica Acta, published in 1995:

> Science, but he also enjoys science fiction films. Teaching introductory science by showing and discussing science fiction films is not only fun but can also offer a way for students who are more interested in the visual arts and humanities to become interested in the physical sciences. Having used a similar approach to teach some of the basics of planetary science to a class of students with diverse interests, I highly recommend this approach (Schneider, 2016).

For this reason, the film Armageddon (1998), one of the space-themed films, was chosen to guide the study. In the film, the issue closely related to the DART project is discussed. "If

an asteroid hits the earth, will live end, how can we prevent such an asteroid from hitting the earth?"

Armageddon (1998) Film Synopsis

In the film, a meteor the size of Texas, which is rapidly approaching the earth and will affect all life on earth in 18 days, is noticed by NASA. NASA devised a plan in which a hole would be drilled in the meteorite before it enters the atmosphere and before it reaches a certain distance, and a nuclear bomb would be placed inside and detonated, thus changing its trajectory. With the inclusion of a third-generation oil drilling company in the project by NASA, the training of the drilling team working in the company to fly to the asteroid in less than twelve days began. Astronomers accompanied the drilling team on the mission to be carried out with two shuttles named Independence and Freedom. While preparations were underway, the news that another meteorite had hit Shanghai and that the large asteroid was rapidly approaching was heard all over the world. According to the plan, two shuttles took off for the mission and docked at the Russian space station for refueling. During refueling, a spark caused a fire and a Russian Cosmonaut had to join the crew, who managed to escape aboard Independence before the space station was destroyed. As they approached the asteroid, Independence was damaged by debris and collisions, resulting in crew fatalities. Survivors from Independence boarded the shuttle's Armadillo to find the Freedom crew, who landed 26 miles from the intended landing site. Since the landing site was 26 miles away from the intended landing site, it was not the soft ground region of the meteorite, but the so-called iron field, which caused the drilling to be slower and more difficult than expected. Even though time delays caused the mission to fail, the President of the United States decided to detonate the bomb remotely from earth. The crew in space defused the bomb and made progress in drilling. A rock storm damaged the remote detonator and the bomb had to be detonated manually. Freedom took off while the manual detonator remained in the meteorite, the bomb was detonated just before the zero barrier, and the planet was saved from a major collision. The astronauts landed safely on earth, completing their mission.

Importance of the Study

Science fiction films play an important role in making students interested and curious about science and scientific knowledge (Bowater et al., 2012; Koeberl, 1995). In addition, studies have revealed that science fiction films can be used to obtain scientific information and as teaching materials. Some of these studies can be exemplified as the study in which the Avatar film was examined for environmental education (Takmaz et al., 2018), the study in which the concept of ethics in which new techniques were examined through different science fiction films on biotechnology was discussed with secondary school 8th grade students (Yazici & Altiparmak, 2010), teaching the concept of immunology in medical education with films about infectious diseases (epidemics, zombie, vampire, etc.) (Schneider, 2016).

In addition, in a study titled "Movies as a source of active teaching methods," 10 movies containing the problem-solving method and a total of 17 scenes in these movies were analyzed. Among these movies are productions such as "Good will hunting" and "Stand and deliver." Especially in the movie "Good will hunting," a character who works as a cleaner and solves complex mathematical problems due to his superior intelligence was presented as an example of problem-solving method (Üzüm & Ünver, 2023). In "Cartoon application in science teaching: Examining the academic achievement and attitudes of primary school students," the effects of educational cartoons on students' academic achievement and attitudes were examined. In this context, students' achievement in science courses and their attitudes toward the course were assessed using cartoons produced by the Ministry of National Education (Yılmaz & Ceylan, 2019). "Using popular films to enhance classroom learning: Integrating Bloom's taxonomy and film clips" examines how popular films can be used to enhance classroom learning. Based on Bloom's Taxonomy, film clips were found to be effective in developing students' critical thinking and problem-solving skills (Butler et al., 2009). The study, "Film as a teaching resource," examined how film can be used as a teaching resource in management and organization courses (Champoux, 1999).

When the literature is reviewed, it is seen that films are mostly used in the social field in scientific studies (Brown, 2012). In the studies conducted using science fiction films, especially the attitudes and opinions of prospective science teachers were investigated (Balbağ et al., 2012; Ozturk, 2017; Tatlı & Şahin, 2020). As it is understood from the literature review, it has been determined that there are a limited number of studies in the form of secondary school students reaching and presenting a real-life project by induction based on a problem in a science fiction film, and for this reason, this study is important.

The study, carried out within the scope of the eTwinning project, started with the following questions: "A large asteroid is approaching earth and you don't have much time to stop it. If the asteroid hits, life on earth will end. How can you prevent this asteroid from hitting the earth?" First stage of the study, the film Armageddon (1998) was watched and analyzed with the students. In the next stage of the study, considering that the world may experience such a problem, students were asked about their knowledge about whether there are real projects that can solve this problem and they were asked to do research. Students who reached the DART project through research were asked to prepare a presentation about this project. The aim of this research was to improve students' research skills and to determine how their interest and knowledge in astronomy changed.

In order to reveal the reflection of today's astronomical developments on children and astronomy education, answers to the following questions were sought in line with the main purpose of the study:

1. Is there a significant difference between the levels of interest of students in astronomy before and after the research?
2. Is there a significant difference between the levels of knowledge of students about astronomy before and after the research?
3. What is the effect of film analysis method and the activities within the scope of eTwinning project, on students' interest levels in astronomy?

4. What is the effect of film analysis methods and the activities within the scope of eTwinning project on students' knowledge levels about astronomy?
5. What is the effect of film analysis methods and the activities within the scope of eTwinning project on students' research skills?

METHODOLOGY

Research Design

This study was conducted to increase students' interest and achievement in astronomy. In the study carried out within the scope of the eTwinning project, weak experimental design has been used. Weak experimental design which is one of the experimental research methods include a single study group and participants are not randomly selected (Büyüköztürk et al., 2008). This research method was determined because volunteers were selected for the study and the study consisted of a single group, that is, only the experimental group.

The implementation process was planned as an eTwinning project and could be carried out systematically, and the process carried out under the supervision of practitioners could be analyzed in detail (Karasu et al., 2015; Mertler, 2009; Somekh, 2005).

In terms of data collection, mixed research method was used since both quantitative and qualitative data were analyzed. Quantitative data were collected using the "solar system and beyond achievement test" and the "scale of interest in astronomy" while qualitative data were collected by implementing the eTwinning activities carried out by the practitioners during the process.

In this study, "solar system and beyond achievement test" and the "scale of interest in astronomy" were applied to the group as pre- and post-test after the application is carried out. It was checked whether there was a significant difference between the students' pre- and post-test scores (Fraenkel et al., 2011).

Working Group

The study was carried out within the scope of the eTwinning project with a total of 54 8th grade students studying in secondary schools in 5 cities of Turkey, namely Ankara, Eskişehir, Adana, Sivas, and Şanlıurfa in the autumn term of 2022-2023 academic year. The researchers found the project partners by contacting the teachers who volunteered to participate in the study through the advertisement they placed on the partner search forums on the eTwinning platform. The students at the schools where the project partners work were included in the project voluntarily, and since the participating students were minors, permission documents were first obtained from their parents.

Data Collection Tools

The quantitative data of the study were obtained with the "solar system and beyond achievement test" (**Appendix A**) developed by Aktamış and Uçar (2019) and the "scale of interest in astronomy" (**Appendix B**) developed by Kılıç and Keleş (2017) and applied as test-retest. The "solar system and beyond achievement test" consisted of 36 multiple-choice questions and the reliability coefficient of the test was 0.94. The "scale of interest in astronomy" consists of 31 items and 3 dimensions: interest in popular astronomy topics (0.93), interest in learning astronomy topics (0.90), interest in technology and careers in astronomy (0.90) and Cronbach's alpha internal consistency coefficient was 0.96. These two scales were preferred because their Cronbach's alpha coefficients were above 0.70, and permissions were obtained from the scale developers for the use of the scale.

Qualitative data were collected by asking predetermined open-ended questions by stopping the film at relevant places while the film was shown to the students (**Appendix C**). Care was taken to ensure that the questions could not be answered as "yes-no." The students were asked to give written answers to the questions and then write their answers under the same questions in the forums on the eTwinning platform. In this way, qualitative data were collected from the eTwinning platform and analyzed.

Implementation Process

In the research conducted with eighth-grade students, a partnership was established as teachers working in five different provinces through the eTwinning portal to observe students' interest and success in astronomy. The students were registered to the ESEP system after each counselor teacher had the students selected from his/her school sign the parental permission documents voluntarily. After each student was given a username and password, they were informed about the link (https://school-education.ec.europa.eu/en/pupil-login) through which they could access the system.

Since it is essential to carry out studies in line with the purpose of eTwinning projects simultaneously, by staying in contact with partners, a road map was created and a work plan was created. At the beginning of the decisions taken at the meeting held with the participation of the students, the Web 2.0 tools to be used were determined. Padlet, Bitmoji, Chatterpix, and Canva Web 2.0 tools were actively used by the students.

The work schedule to be followed by all partners during the study period is designed as shown in **Table 1**.

To guide the students on what to do within the scope of the research, the project page layout was set so that it could be seen by the teachers and students involved in the study (**Figure 1**). The qualitative data of the research were collected with the questions directed to the students in the forums section of the project page layout. In the page layout, the objective of the study is expressed as follows:

> 'In our project, we aim to gain students' research skills and problem-solving skills with video assisted learning methods. In this direction, the space-themed film Armageddon (1998) will be watched and various questions will be asked to the students by examining the scientific themes covered in each part of the film. Within the scope of the subject of the film content, real-life projects will be researched and presented by the students. In this way, the student's ability to express themselves, to speak in front of the public will

Table 1. Project schedule

Week	Planned activities
Week 1 (21.11.2022-28.11.2022)	*Application of student pre-tests (interest scale and achievement test) *Partners meeting (teacher-student)
Week 2-4 (29.11.2022-18.12.2022)	*Asking for the problem sentence of the students and taking the solution suggestions. *Watching and analyzing the film Armageddon (1998) *Investigation of scientific research, applications, and experiments on this subject by students
Week 5 (19.12.2022-25.12.2022)	*Students researching and presenting the DART project
Week 6 (26.12.2022-30.12.2022)	*Application of student post-tests (interest scale and achievement test) *Project end meeting (teacher-student): Receiving opinions and suggestions about the project

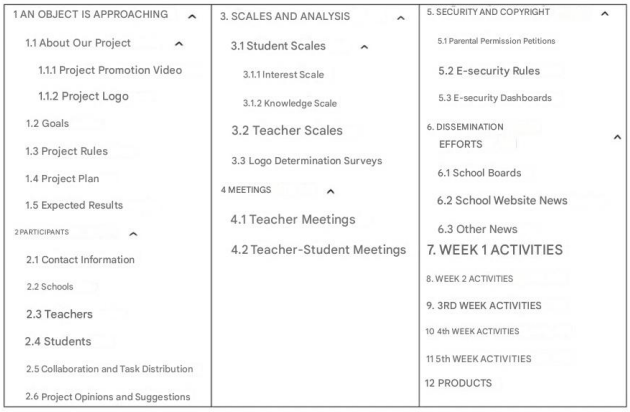

Figure 1. Project page layout (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

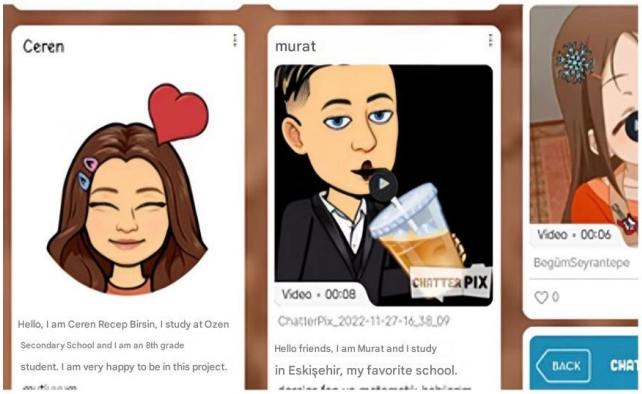

Figure 2. Adding student introductions created by students with the Web 2.0 tools on the padlets (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

> improve, and it will also be ensured that the student learns how to conduct scientific research.'

Administering the pre-tests

To collect quantitative data, the "solar system and beyond achievement test" and the "scale of interest in astronomy" were administered as pre-test to a total of 54 students from five different schools.

Use of Web2.0 tools

After the general objectives of the study were determined, each teacher introduced himself/herself and his/her school. While introducing themselves, the teachers preferred to explain themselves by writing, and while introducing their schools, they preferred to add the existing school introduction videos to the relevant fields. In addition, each teacher added 2 padlets created with Web 2.0 tools to the areas designated for him/her in the meeting. The padlets were embedded in the relevant areas on the eTwinning page to ensure that student and teacher interactions were organized. For the students to introduce themselves, methods were used in which their open names were not used within the ethical rules and their visuals were not included. The funniest way to do this was to ask students to install bitmoji and chatterpix applications from Web 2.0 tools on their phones or computers. They created an avatar for themselves with the Bitmoji application, opened the avatar they created in the chatterpix application, selected the image they wanted, and made the avatar picture speak. They entered their chatterpixs, which they introduced themselves, into the system with their usernames and passwords and added them under the padlet with the name of their schools (**Figure 2**).

Students were asked to create a project logo using Canva web2.0 tool. Each student designed a logo and the designed logos were presented for voting with the questionnaires created through google forms. The winning logo from each school was presented to the voting with a survey again and the winning logo was determined as the project logo as a result of the last survey (see **Figure 3**).

Figure 3. The winning logos of each school as a result of the survey (on the left four logos) and the project logo selected by the final vote (on the right) (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

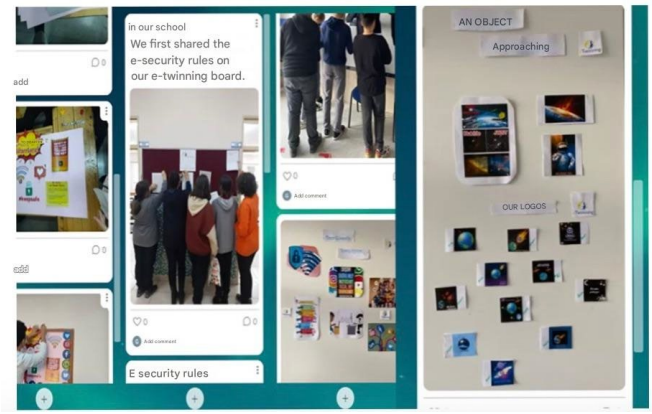

Figure 4. E-safety and project promotion boards prepared with students (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

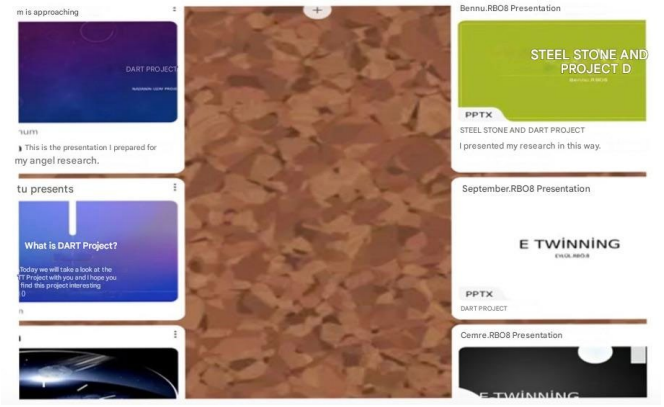

Figure 6. Presentations prepared by the students (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

Figure 5. Students watching a film (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

Figure 7. Frames from the videos of students presenting their research (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

Dissemination studies

To disseminate the work and raise awareness in all five schools, each school simultaneously created a project promotion board and an e-safety board in their schools. The visuals of the boards created by each school were added to the padlets under the relevant title on the eTwinning page (see **Figure 4**).

Film watching within the scope of study

To collect qualitative data with the questions to be directed to the students, the film Armageddon (1998) was watched in a way to brainstorm by stopping in some parts. The Armageddon (1998) film was divided into three parts and it was determined by meetings with our counselor teachers that we would watch one part of the film every week (see **Figure 5**). The open-ended questions to be asked at which minute were prepared in advance, and the questions were directed at the students during the film watching each week. Students wrote their ideas by logging in to their eTwinning pages so that everyone in the study could see them.

Directing students to DART project

After the film was over, considering that the world may experience such a problem, students were asked about their knowledge about whether there are real projects that can solve this problem and they were asked to do research. Students who reached the DART project carried out by NASA were asked to prepare a presentation related to their research to present to their classmates (see **Figure 6**).

The students were asked to present the prepared slides to the other classes in their schools and to disseminate the project products by announcing them to the whole school. In this process, while the students were making presentations (see **Figure 7**), video recordings were taken, taking care not to show their faces, and shared on YouTube with the "unlisted" option and uploaded to the eTwinning portal, ensuring that only those who have the link can see the videos.

Administering the post-tests

To collect quantitative data, the "solar system and beyond achievement test" and "scale of interest in astronomy" was administered to the same 54 students studying in five different schools as a post-test.

The expected results were expressed by the project founders as follows:

> The main purpose of our project is to develop research skills of students and to increase students' interest in astronomy.

Table 2. t-test results of interest test pre- and post-test mean scores

Interest test	N	Mean	Standard deviation	df	t	p
Pre-test	54	130.50	12.055	53	-7.319	.000
Post-test	54	142.57	9.807			

Table 3. Wilcoxon rank test results of At test and the median of differences between pre- and post-test

Achievement test	N	Mean	Nonparametric test	p
Pre-test	54	29.20	Related-samples Wilcoxon signed rank test	.081
Post-test	54	30.43		

- Students within the scope of the project
- Scientific process skills
- Problem-solving skills
- Self-expression
- To work in co-operation

It is aimed at improving terms of self-efficacy. At the end of the project, the analysis of the data will be concluded with an article.

Analyzing the Data

SPSS 21.0 statistical package program was used for the analysis of quantitative data. It was determined that the data obtained were normally distributed. For this reason, the scores obtained from the pre- and post-test in both the interest scale and the achievement test were compared separately by t-test.

In the qualitative data section, the responses obtained from the students were reported by the researchers, and the data were analyzed through this report.

FINDINGS

Findings From Quantitative Data

At the beginning and the end of the research process, the "scale of interest in astronomy" and the achievement test developed for the "solar system and beyond" unit was applied to the students in pre-/post-test format. When analyzing the quantitative data, the pre- and post-test scores of the sample group of 54 students were evaluated for both tests. For the astronomy interest test, the dependent groups t-test was used as the test scores showed a normal distribution. Since it was found that the astronomy achievement test scores did not have a normal distribution, the paired samples Wilcoxon test, one of the non-parametric tests, was used.

The working group is called the t-test results of the pre- and post-test scores obtained from the five-point Likert scale applied on the subject of "interest in astronomy" are given in **Table 2**. According to **Table 2**, there was a statistically significant difference between the mean scores obtained from the questionnaire questions before and after the application in favor of the post-test ($p < .05$, $t = -7.319$). While the interest scores of the students were mean (M) = 130.50 before the application, they increased to M = 142.57 after the study. According to these findings, it can be said that the activities carried out in the study process positively affected the students' interest in astronomy.

The nonparametric Wilcoxon test results of the pre- and post-test of the achievement test developed for the "solar system and beyond" subject applied to the study group are given in **Table 3**. According to **Table 3**, there was no significant difference between the pre- and post-test scores obtained from multiple-choice questions ($p > .05$). Although the average of the test scores increased from 29.20 to 30.43, this increase does not constitute a statistically significant difference since the significance value is $p = .081$. Therefore, it can be said that this study did not have a positive or negative effect on the astronomy achievement of the students.

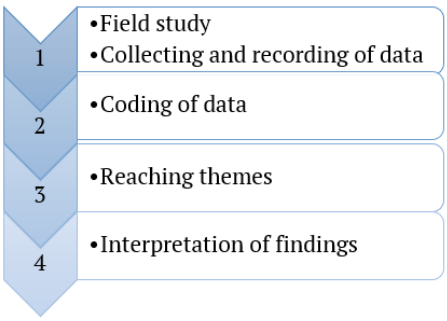

Figure 8. Content analysis process of qualitative data (Source: Developed by the researchers to enhance the understanding of the project steps)

Findings From Qualitative Data

The qualitative data of the research were obtained by the students answering the open-ended questions structured by the project partners during the viewing of the film. At the specified minutes of the film, the film was stopped and the relevant questions were directed at the students. The students wrote their answers under the relevant question in the "forums" tab of the project on the eTwinning portal. The answers were reported by the researchers. According to McMillan and Schumacher (2010), the process of content analysis of qualitative data was planned and the information obtained from the report was analyzed and the themes were reached by finding the conceptual meanings of the codes by dividing them into meaningful codes (see **Figure 8**).

The questions asked to the students throughout the study were grouped under 3 themes since they aimed to measure inductive reasoning, empathy, and problem-solving skills (see **Figure 9**).

During the study, seven-teen open-ended questions were asked to the students for 3 weeks. The number of answers written under the questions on the portal varies. This is because the answers were asked to be written voluntarily. The irrelevant ones were removed from these data and codes were created by using the expressions of similar answers. The codes,

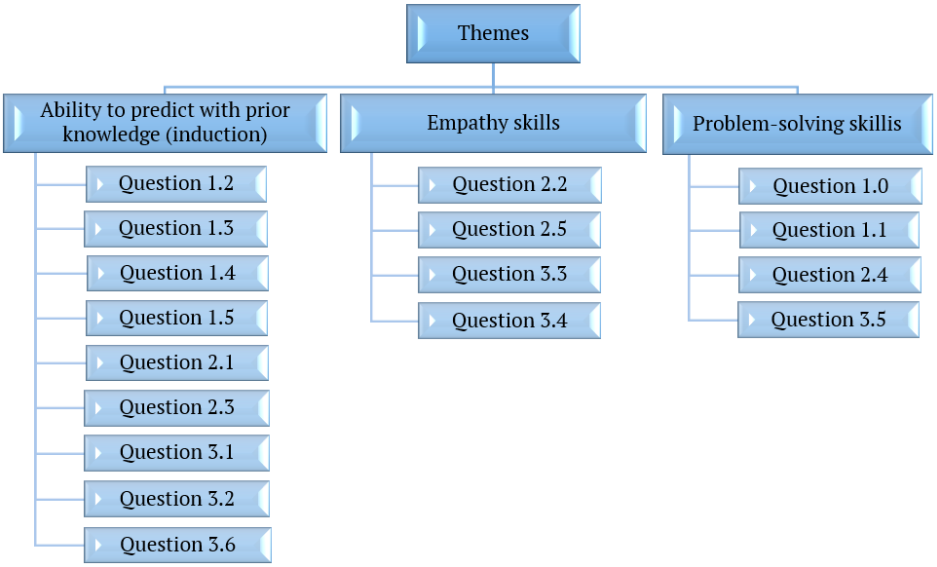

Figure 9. Themes generated during the analysis of open-ended questions (Source: Developed by the researchers to enhance the understanding of the project steps)

Table 4. Question 1.0 frequency table

"An asteroid is approaching the earth. Life will end, how would you prevent it from crashing?"	Frequency	Percentage
I would detonate it with a nuclear missile/bomb.	12	38.7
I'd send people to other planets.	1	3.2
I'd shatter it with rays/lasers.	6	19.4
I would try to change the direction/path of the asteroid.	4	12.9
I would make a technological device/shield covering the earth.	3	9.7

Table 5. Question 1.1 frequency table

"If you were on the NASA team, what kind of solution would you produce?"	Frequency	Percentage
I'd blow it up with a nuclear missile/bomb.	19	50.0
I'd send people to other planets.	2	5.3
I'd blast it with beams/lasers.	2	5.3
I would try to change the asteroid's direction/path.	5	13.2
I'd protect it with a technological device/earth-covering shield.	3	7.9
I would build a team.	4	10.5
I used to study it with the Hubble telescope.	2	5.3

frequency/percentage tables, and findings determined for each question are as follows.

At the beginning of the study, a problem was stated before the film was started to be watched and the question "An asteroid is approaching the earth, if it hits, life will end, how would you prevent it from crashing?" was asked. Among the 31 answers given, the expression "I would detonate it with a nuclear missile/bomb" was the most common (see **Table 4**).

In the first 20 minutes of the film, the problem situation was identified and NASA teams started planning to produce solutions. In this section, the students were asked the question "If you were on the NASA team, what kind of solution would you produce?" It can be thought to be a parallel question with the first question, but here the problem was explained concretely and students were asked to produce a serious solution with the brainstorming technique.

The answers were similar to the previous question and the most common answer among 38 answers was "I would blow it with a nuclear missile/bomb."

Answers were diversified with expressions such as "I would organize a team" and "I would make observations with the Hubble telescope" (see **Table 5**). In the first question, when the students were asked what kind of solution could be produced in case of an extraterrestrial threat, the reason why the answer "I would blow it up with a missile, I would smash it" was among the most common answers that can be attributed to the space-related films made so far. Another interesting answer given by three student is "I would protect the earth with a shield covering it." This statement shows that three students have a misconception about the scales of celestial bodies. With the answer "I would try to change the direction of the asteroid," it was determined that five students thought in the same logic as the developers of the DART project. With the answer "I would send people to other planets," it is stated that the students think that there are other habitable planets other than earth and that these planets can be easily accessed and therefore they have misconceptions about the distances between celestial bodies.

Following questions were asked to the students to determine their prior knowledge of them: "We see that they did not have a plan against such extraterrestrial threats before and were caught unprepared. So are we prepared for real life?

Table 6. Question 1.2 frequency table

"In real life for planetary defense, are we prepared? Has work been done for this?"	Frequency	Percentage
We are not prepared.	19	57.6
Not heard.	4	12.0
Probably there are.	6	18.2
I heard I don't know the details.	2	6.1
There is.	2	6.1

Table 7. Question 1.3 frequency table

"How do you think the teams in the film will cross paths?"	Frequency	Percentage
They will cooperate in exploding the asteroid.	22	64.7
They will produce solutions related to oil.	5	14.7
Meteorites will fall/study.	6	17.6
They won't intersect, they're irrelevant.	3	8.8

Table 8. Question 1.4 frequency table

"How could they have determined the asteroid landing site?"	Frequency	Percentage
Through satellites/space telescopes.	22	64.7
By sending a spacecraft/probe.	4	11.8

Table 9. Question 1.5 frequency table

"What is the reason for the tests on the oil crew?"	Frequency	Percentage
It is being done to see if it can adapt to zero gravity environment/space.	32	97.0

Table 10. Question 2.1 frequency table

"Why is the gravitational force in asteroids maybe as little as on the moon?"	Frequency	Percentage
Small mass.	18	62.0
Little atmosphere.	6	21.0
It is part of the moon.	3	10.3

Are there projects developed for this? Have you heard of any projects before?" Of the 33 answers given to this question, the most common answer was "I think we are not prepared." On the other hand it was seen that the answer was "I heard I don't know the details" was given by two students. It was determined that two students who answered had prior knowledge about the subject (see **Table 6**).

The question "We see two different teams in the film, how will the paths of these two teams cross?" aimed to predict the next step in the film. More than half of the 34 answers given to this question were as "They will cooperate to blow up the asteroid" (see **Table 7**). Although their predictions were correct, when asked what kind of cooperation they would make, they said, "They will produce a solution related to oil."

Another the answer was "A meteorite will fall to earth and they will analyze it." It can be said that the students who expressed this way did not understand the directive that living life would end as a result of the fall of the meteorite on the earth.

"The team said they would land on soft ground for Asteriote landing. How could they have detected this soft ground?", the majority of the 34 answers were "through satellites and space telescopes." The fact that precise measurements can be made with the help of space telescopes is the correct inference of about 65 percent of the students. "They could have sent a rocket/probe to the meteorite and analyzed the meteorite" (see **Table 8**). With this statement, it was determined that the students lacked knowledge about the preparation processes of space missions and the realization stages of the programs.

"We see that some tests are being conducted on our petrol crew. What do you think is the reason for these tests? Do astronauts undergo such tests in real life?" 97 percent of the answers to the question "Tests are conducted to prepare them for space life. In reality, astronauts also go through such tests" (see **Table 9**). It can be concluded that the students know this subject.

More than half of the 29 answers given to the question "Why can the gravitational force on a meteorite be less than on the moon?" were expressed as "Because the mass of the earth and the gravitational force of the earth are more than the mass of the meteorite and the moon, and the mass of the meteorite and the moon is less" (see **Table 10**). Grade 7 science students can be said to understand the law of gravitation correctly. The answers "Because it has less atmosphere" and "It may be a part of the moon" indicate misconceptions and lack of knowledge.

Half of the students out of 24 answers to the question "When there was a leakage during fuel transfer, the pressure increased, what kind of a solution would you think of in such a situation?" answered, "I would immediately remove the whole team from there because there could have been an explosion." Approximately 34 percent of the answers were expressions aimed at solving the problem (see **Table 11**). The statements "I would first switch off the electricity, then connect the valve and switch it back on," "Because the fuel leaked out. I would try to prevent the leakage," and "I would stick tape where the

Table 11. Question 2.2 frequency table

"In case of pressure rise during fuel transfer, what would you do?"	Frequency	Percentage
I would run away.	12	50.0
I would try to solve the problem.	8	33.3

Table 12. Question 2.3 frequency table

"What is the effect of ferrum on the loss of communication?"	Frequency	Percentage
He created a magnetic force/field.	20	71.4
It is due to the conductivity of ferrum.	5	17.9
Radio waves are blocked by ferrum.	1	3.5

Table 13. Question 2.4 frequency table

"You survived an accident in space alone, what would you do to survive?"	Frequency	Percentage
I'd try to contact earth/the other team and call for help.	21	75.0
I'd try to fix the car.	3	11.0
I would wait to die.	3	11.0

Table 14. Question 2.5 frequency table

"If you were the President of the United States, would you detonate the bomb?"	Frequency	Percentage
I'd give the order to blow it up.	7	24.1
I wouldn't blow it up, I'd trust the team.	21	72.4

Table 15. Question 3.1 frequency table

"Why did they need thrusters to descend?"	Frequency	Percentage
Since there is no/little gravity.	23	82.1

leakage was" show that the students cannot predict the complexity of space technologies and space conditions.

"The fact that they landed in the ferrum field caused them to lose the connection, what do you think is the main reason? What is the effect of ferrum here?" 20 students answered the question "The connection may have been lost due to the magnetic effect of ferrum." It can be said that their predictions are acceptable here. In addition, "Since ferrum is an electrical conductor, it may have caused interference." Expressions such as "It may be due to the blocking of radio waves by ferrum" are indicators that they have concept confusion (see **Table 12**).

"You survived a space accident alone. What would you do to survive and get out?", they were asked to put themselves in the shoes of the film characters and think. Among the 28 answers, 21 of them are as follows "I would try to communicate, I would use oxygen sparingly, I would try to survive until help arrives." In addition, three students said, "I would try to repair the spacecraft" while the other three students stated that they would exhibit submissive behavior by saying "I would not do anything, I would jump into space and die" (see **Table 13**).

"The American President was expected to decide. What decision did he make? What decision would you have made?", 21 students answered to the question "The American president gave the order to activate the bomb. I would have trusted him and waited a little longer." While students chose to take risks, 7 students chose not to risk the responsibility of all the citizens of the world by thinking more realistically by saying "He gave the order to detonate the bomb" (see **Table 14**). Another answer was "I would have made the same decision. because if we detonate the bomb, a few people may die, but if we do not detonate the bomb, the whole world may die."

"While the other team was coming to help, they hit a rock and got damaged, the thrusters did not work and they started to ascend. Why did they need thrusters to descend?" 23 of the 28 answers to the question "They could not land on the ground because there was no gravity. That's why they needed thrusters" (see **Table 15**). Since this is an explanation made during the training of the crew in the film, it can be concluded that those who gave this answer were careful listeners.

"When they were making the second attempt, they came across the gas pocket, the concussion started and the explosion failed. What could this gas pocket be and could this situation have been taken advantage of? How?" half of the 28 answered the question "Maybe after the explosion, a hole of the size they wanted to open for the bomb could have been opened." Eleven students stated that they could not understand the gas pocket (see **Table 16**).

"The remote control of the bomb was broken. How and what would you decide at such a moment?" 16 out of 28 students answered this question as "One person would have to make a sacrifice" and "I would sacrifice myself, at least the world would be saved and I would be called the savior of the world." Their statements showed that they thought in the same direction as in the film. Seven students chose to struggle as "I would try to fix the remote control" and 3 students wanted to live by seeing it appropriate for someone else to do it (see **Table 17**).

Concerning the straw drawing process to decide who will stay, 24 out of 28 answers to the question "What would you decide if the short straw came to you?" stated that they would sacrifice themselves by saying "I would stay, after all, we will save so many people," while 4 said "I would complain and insist that we take it again" (see **Table 18**).

Table 16. Question 3.2 frequency table

"What is a gas pocket and if it was detected in advance in this case could it be used to advantage?"	Frequency	Percentage
Advantages/easier to drill.	14	50.0
Not an advantage.	3	10.7
Undecided/I don't know.	11	39.3

Table 17. Question 3.3 frequency table

"The remote control of the bomb is broken. That's how and what decision would you make at a moment's notice?"	Frequency	Percentage
One person can blow up a mold.	16	57.1
I would try to fix it.	7	25.0
Let someone else do it.	3	10.7

Table 18. Question 3.4 frequency table

"What decision would you make if the short straw came to you?"	Frequency	Percentage
I would sacrifice myself for humanity.	24	85.7
No, I would have accepted.	4	14.3

Table 19. Question 3.5 frequency table

"Ignition failure during take-off. What would you do in this case?"	Frequency	Percentage
I'd try to fix it.	26	93.0

Table 20. Question 3.6 frequency table

"Why do you observe the movement of the asteroid when you are on the asteroid? They didn't feel it?"	Frequency	Percentage
Due to gravity.	7	33.3
Size difference.	3	14.3
Because they act together.	10	47.6

"The igniters did not work during take-off. How would you solve the problem?" 26 out of 28 answers to the question "I would identify the source of the problem and try to repair it." "I would try everything in my power to repair it" (see **Table 19**). In this case, it was observed that the students made decisions in parallel with the film.

Ten out of 21 answers to the question "The asteroid was rapidly approaching the earth, so why didn't they feel the movement of the asteroid when they landed on the asteroid?" were "They didn't feel the rotation of the earth, just as we don't feel the rotation of the earth." It can be interpreted that the other students (see **Table 20**) who used expressions such as "They did not feel it because of the gravitational force and because it was coming fast" and "They may not have felt it because the earth was bigger than the meteorite" had misconceptions.

After watching the film, the students were asked to investigate whether there is any preparation and/or work done in the world for a similar defense system and to present their research.

It was seen that all of the students participating in the e-twinning project reached the DART project as a result of their research (**Figure 10**).

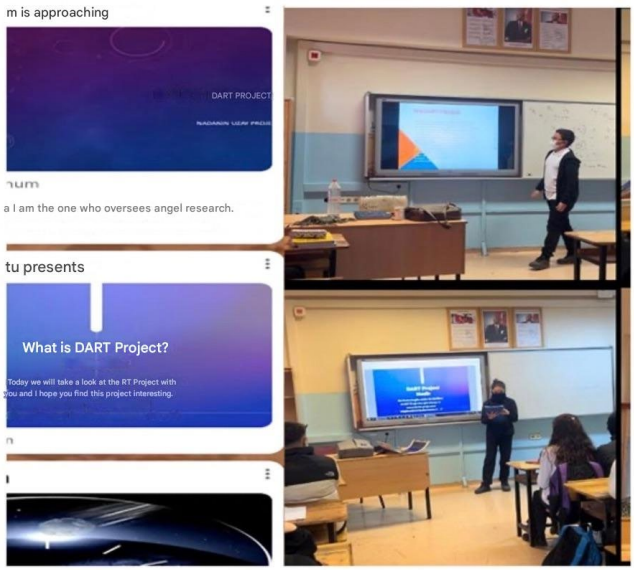

Figure 10. Presentations prepared by the students (Source: https://school-education.ec.europa.eu/en/etwinning/projects/bir-cisim-yaklasiyor)

CONCLUSION

In this study, the effectiveness of the real-life science fiction film analysis method, which aimed to improve the research skills of eighth-grade students, on their interest and knowledge about astronomy was examined. With the applied study, it was investigated to what extent the students' interest in astronomy and their achievement in this subject differed. In line with the research, the interest scale and achievement test were applied as pre- and post-test. With the application of open-ended questions, students were allowed to express themselves about the subject.

When the pre- and post-tests were analyzed, it was concluded that the students' interest in astronomy increased significantly before and after the study. The reason for the low level of interest of the students in the pre-test phase can be

said to be the lack of perspective on astronomy and their sense of curiosity. With the sense of curiosity aroused in the students during the study, it can be said that their interest was increased and their sense of curiosity was triggered by the brainstorming and questions directed while watching the film. It was observed that the average test scores of the students' achievement towards astronomy increased slightly as a result of the study, but this did not create a significant difference. This situation can be attributed to the fact that during the study, students' predictions and thoughts about the film were mostly taken, and students were directed to the DART project apart from the subjects in the "solar system and beyond" unit and they only investigated this subject.

With the questions asked during the viewing of the Armageddon (1998) film, it was aimed for the students to predict what might happen in the film and to develop their problem-solving skills with the question "what would you do if you were you?" As the first question, students were asked what could be done when they encountered a situation like the one in the film, and students were asked to produce solutions. The students' suggestion of detonating the asteroid with a nuclear bomb as a solution to the danger of an asteroid hitting the earth is an indication that they can produce solutions close to reality when they think about the subject.

Answers to the question "Are we ready for planetary defense in real life? Has work been done for this?" showed that only two students were aware of the DART project. At the end of the study, the fact that all students made a presentation about the DART project can be interpreted as an increase in their research skills.

The students who answered the question about the cooperation of the teams in the film as "A meteorite will fall to the earth and they will analyze it" are an indication that they are not aware of the danger of the destruction of living life when a meteorite falls to the earth.

The qualitative data in **Table 8** and **Table 9** show that the students have knowledge about space technologies and that they know that preparations should be made for those who will go to space to adapt to the zero-gravity environment. This can be interpreted as that secondary school students are interested in astronomy.

Table 10 and **Table 15** data indicate that a large portion of the students have correctly understood the law of gravitation; however, some students possess incorrect information, believing that asteroids have atmospheres.

Interpretation of qualitative data, with the questions asked during the viewing of the Armageddon (1998) film, was aimed at enabling the students to predict what might happen in the film, and to develop their problem-solving skills by asking "what would you do if you were you?" Questioning what can be done when faced with a situation like the one in the film, which is the reason for the project, has made them turn to the DART project by enabling them to investigate through induction.

Today, although it is an advantage to have easy access to information thanks to technology, this has led to laziness and atrophy of scientific research skills. In the research assignments given to the students, it is common for them to copy and bring the information from the first web page that appears when they type in the search engine without checking its accuracy. It is very important to teach students that the information on the internet is mostly wrong and that the way to reach the correct information is to check the accuracy of the information from many different sources. In this study, without giving information about the DART project, students were enabled to reach the DART project as a result of scientific research.

By preparing the information they obtained in the form of a presentation and presenting it to their friends, it was ensured that they could speak and express themselves in front of the public and thus contributed to the development of their self-confidence.

While preparing their presentations, some of the students brought extra visual materials to the class, found the animation of the DART project made by NASA, showed it to their friends, and enriched and supported their presentations. In this way, they contributed to their friends who did not have information about the DART project to understand the project more easily.

Due to the intense content of the curriculum, there is no time for such studies due to the teacher's rush to catch up with the subjects. In addition, it has been observed that 8th graders have difficulty finding time for studies at this grade level due to their preparation for the high school entrance examination. For this reason, although some students wanted to participate in the study, they left the study.

Astronomy has an important place in science education in terms of developing students' sense of curiosity, imagination, and discovery and making them love science lessons (Aksan & Çelikler, 2017; Tunca, 2002). Accurate astronomy education is one of the most effective ways to encourage scientific curiosity, research, questioning, methodical work, comparison, and observation in students from primary school onwards. Since astronomy is an interesting field, it directs students to science and technology and improves their level of understanding in the field of education, and increases their perceptions (Çiv et al., 2022; Demir, 2020). The fact that astronomy subjects are abstract and difficult to understand students has led to an increase in the number of studies on this subject (Aktamış & Arıcı, 2013; Oğuzman et al., 2021). The use of simulation, video, and picture display can increase students' interest in teaching astronomy subjects in schools and facilitate learning. It is possible to improve individuals' spatial thinking skills with activities in astronomy science (Çiv et al., 2022; Taşcan, 2019), by updating the curricula on modeling and material use.

DISCUSSION

Teachers' not being aware of new information about astronomy, not using materials or not being aware of the materials from which they can get accurate information about astronomy, choosing the wrong sources, and administrators not giving importance to astronomy education cause misconceptions about astronomy to occur (Raviv & Dadon, 2021).

To minimize the problems encountered, countries need to allocate more funds to science education in order to improve astronomy education within a universal framework (Bitzenbauer, 2023; Ferrari et al., 2024).

It is also important for countries to inform the public about changing knowledge and developments in the field of astronomy and to continuously update the curriculum in line with these developments (Salimpour, 2024), as well as to ensure that the information conveyed through the media is accurate.

It is recommended that planetariums, museums, parks, and science centers be expanded (Chong et al., 2025).

Astronomy is part of physics, and 'astronomy literacy' should be taught to students from an early age through astronomy education. Jelinek's (2021) study with children aged 5-10 emphasizes the importance of astronomy education at an early age.

Today, the younger generation we are trying to raise without up-to-date knowledge of astronomy faces not only serious problems such as educational deficiencies and incompatibility with modern science, but also the problem of failing to keep pace with the requirements of this era, in which space stations are being established, artificial satellites are being used in every field, and space research is developing very rapidly. To address this problem, the aim should be to increase the curiosity and interest of the younger generation in the science of astronomy (Colantonio et al., 2021). To increase curiosity, different techniques such as interactive games and drama should be used in schools (Akimkhanova et al., 2023).

For students to be aware of the threats awaiting the earth, it is important to carry out projects on astronomy. In this way, it can be comprehended that space is not just about films and that threats are real.

To improve students' research skills, more studies can be carried out to enable students to access information through induction (Chong et al., 2025). It was determined that they were most excited while presenting the information they researched and tended to read what was written in the presentation instead of telling. For this, areas where students can express themselves more should be created.

Time should be made available for student-centered work (Kurniawan, 2021), which can only be achieved by reducing the intensity of the curriculum and the absence of exam anxiety.

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Ethics declaration: This study was conducted within the scope of the project created on the eTwinning platform. All participants (teachers and students) are included in the projects carried out on the eTwinning platform on a voluntary basis with a consent form. These projects, which are carried out in partnership with the Ministry of National Education and the European Agency, are carried out in accordance with ethical rules. In addition, the parents of all students were informed and consent forms were signed. In addition, no images, information, etc. that would reveal the identity of the student were shared within the project and in the research.

Declaration of interest: The authors declare that they have no competing interests.

Availability of data and materials: All data generated or analyzed during this study are available for sharing when appropriate request is directed to corresponding author.

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APPENDIX A: SOLAR SYSTEM AND BEYOND ACHIEVEMENT TEST (QUANTITATIVE DATA SOURCE-1)

SOLAR SYSTEM AND BEYOND UNIT SUCCESS TEST

1. Gamze has found the following information in her research on space technologies. Which of the information Gamze has found is incorrect?

A) Turksat 1B, 1C, 2A are artificial satellites sent into space by our country for communication purposes.

B) Space probes are vehicles sent into space to examine and obtain information about planets, galaxies and other celestial bodies.

C) Space shuttles expend a small amount of energy while going into space.

D) Space stations were established to conduct research and experiments that cannot be carried out on earth.

2.

a. artificial satellite	b. Microscope	c. Space Stations
d. Magnifying glass	to. space shuttle	f. space suit

What technologies have been developed for space exploration?

A) a,b,c,e B) a,c,e,f
C) a,c,d,f D) a,b,c,f

3.

Selçuk is preparing the visuals above for a Science class presentation. Which of the following could be the topic of Selçuk's presentation?

A) Tools developed for space technologies
B) Unidentified objects in space
C) Tools used to clean space
D) Structures in the solar system

4. Which of the following is not among the problems that may be caused by space pollution?

A) Satellites whose mission has ended may fall out of orbit and fall to the earth.
B) It may negatively affect space exploration.
C) It may cause damage to vehicles sent into space.
D) It may cause air pollution.

5. What is the main point of the picture below?

A) Space pollution B) Natural satellites
C) Earth's satellites D) Moon's satellites

6. Teacher Derya: What precautions can be taken to prevent space pollution?

Berk: Satellites whose missions have ended should be brought down to Earth in a controlled manner.

Gözde: Space exploration should be terminated.

Sevgi: Projects that will prevent space pollution should be developed.

Which of the students answered Derya Teacher's question correctly?

A) Gözde and Berk B) Favorite and Love
C) Berk and Love D) Gözde, Berk and Sevgi

7.

1. Objects placed into Earth orbit by humans are called	a. Space Probe
2. It is the space base where experiments and studies are carried out.	b. Space Shuttle
3. It is a vehicle that is sent into space to collect information.	c. Artificial Satellite
4. They are reusable spacecraft.	d. Space station

Which option best matches the descriptions given above?

A)	B)	C)	D)
1-a	1-b	1-c	1-c
2-d	2-a	2-d	2-d
3-c	3-c	3-a	3-b
4-b	4-d	4-b	4-a

8. The effect caused by man-made equipment that has become obsolete over time and orbits the Earth is called.....

Which of the following can be put in the blank to complete the sentence above correctly?

A) Air pollution B) Space pollution
C) Space technology D) Space shield

9. Thanks to space research, there have been many advances in technology. These technologies have led to the emergence of some of the products we use today. For example, ... is one of these products.

In the blank space in the paragraph above, fill in the following:
Which cannot be written?

A) Ballpoint pen B) Aluminum foil
C) Wheel D) Braces

10. Light pollution limits observations from Earth using telescopes. It was invented to solve these problems. The Hubble Telescope is one ..... example. Which of the following should be placed in the blank space?

A) Radio telescope B) Space telescope
C) Lensscope D) Mirror telescope

11.

I. Thanks to space research, new technologies that make our daily lives easier may emerge.

II. Thanks to the developing technology, human travel to Mars may begin in the coming years.

III. Advances in technology prevent astronauts from going into space and conducting research.

Which of the above statements is/are correct?

A) Only I B) Only III
C) I and II D) I, II and III

12.

I. Telescopes contain mirrors or lenses in their structure.

II. Thanks to space telescopes, images of objects in space can be obtained.

III. The clearest images are obtained with telescopes located on the ground.

Which of the above statements
Is it true?

A) Only I B) Only III
C) I and II D) I, II and III

13. Many telescopes of different sizes are used today. Which of the following information about telescopes is false?

A) Telescopes contain mirrors or lenses in their structure.

B) Italian scientist Galileo used the telescope to observe the sky for the first time.

C) Space observations became easier with the invention of the telescope.

D) Small and featureless telescopes enable us to obtain information about faint and distant celestial objects.

14. Which of the following is not one of the contributions of the telescope to astronomy?

A) It provided a better understanding of the structure of the universe.

B) The Earth and the Sun are part of the Milky Way galaxy
It was found to be part of

C) It has been determined that the planets revolve around the Sun.

D) It did not enable the discovery of stars.

15. The following options contain statements about observatories (observatories). Which statement is incorrect?

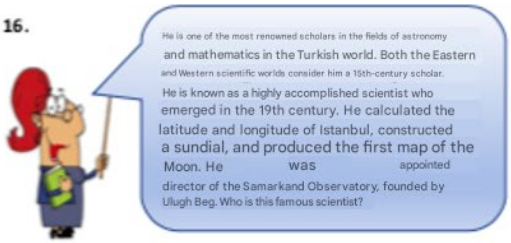
A) To observe space best, observatories are built in high places where the weather is clear throughout the year.

B) All kinds of changes occurring in the sky
It is established to observe, examine and gather information.

C) Observatories for studying the sky are usually located in cities.
It is installed in places close to the lights.

D) It is established to contribute to a better understanding of the universe.

16.



Which option correctly answers the question asked by the teacher?

A) Mimar Sinan B) Biruni
C) Harez? D) Ali Kuşçu

17.

1. With the invention of the telescope, space observations were made in more detail.

II. Observatories are established in city centers to facilitate space research.

III. Studies carried out in observatories are carried out only with telescopes.

is carried out.

Which of the above information is correct?

A) Only I B) Only III
C) I ve II D) II and III

18.

1	Ali Kuşçu	4	Galileo Galilei
2	Graham Bell	5	John Dalton
3	Neil Armstrong	6	Ulugh Beg

Which of the above scientists contributed to the development of astronomy?

A) 1,3,4,6 B) 1,3,5,6 C) 1,2,5,6 D) 1,2,4,6

19.

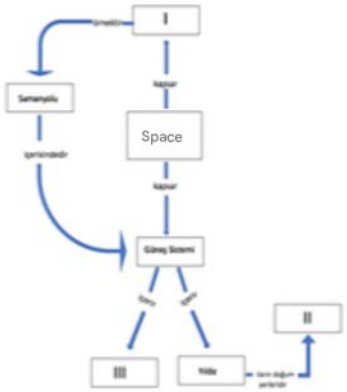
Which of the above materials do we need to make a simple telescope model?

A) I, II, III and IV B) I, II, III and V
C) I, II, V and VI D) I, II, III and VI

20. The following options contain statements about nebulae. Accordingly;
1. The nebula consists of dust, hydrogen gas, and small amounts of other elements found in the interstellar medium.
The core of the star is formed as a result of the merging of many nebulae.
III. Nebulae are abundant in the interstellar medium during the star formation process.
Which of the given statements are correct?

A) Well B) I and III
C) II and III D) I, II and III

21.



Which of the following statements should go in the numbered places in the concept map above?

A)	Galaxy	nebula	Andromeda
B)	Planet	Sun	nebula
C)	Galaxy	nebula	Planet
D)	Planet	World	Month

22.

Which of the following information is incorrect regarding the concept written on the card?
A) It is an object composed of dense interstellar matter.
B) Gas or dust particles clumping together emerges.
C) It is located only in the Milky Way galaxy.
D) They may be the remnants of explosions resulting from the deaths of massive stars.

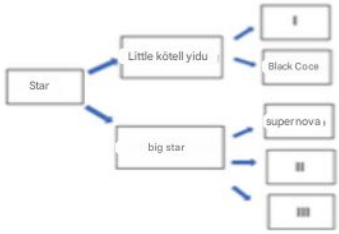
23. Which of the following options correctly lists the structures that form at the end of the stars' lives?

A) Galaxy, White Dwarf, Black Hole
B) Neutron Star, Galaxy, White Dwarf
C) White Dwarf, Black Hole, Neutron Star
D) Neutron Star, Black Hole, Galaxy

24.
L. The compressed cloud of gas and dust comes together to form the core of the star.
II. Hydrogen atoms combine within the core to produce energy. As a result, the star begins to emit light into space.
III. Stars form in high-density clouds.
IV. Interstellar gas and dust begin to compress as a result of explosions occurring within structures called nebulae.
The star formation processes are given above in a mixed manner.
Which of the following is the order of occurrence?

A) III-I-IV-II B) III-IV-I-II
C) III- II-I- IV D) III- IV-II-I

25.



Which of the following expressions should go in the numbered places in the concept map above?

A) Black hole	Planet	White Dwarf
B) White Dwarf	Neutron Star	Galaxy
C) Black hole	Planet	Neutron Star
D) White Dwarf	Neutron Star	black hole

26.

1. It is a part of the universe outside the Earth.	a. nebula
2. It is formed as a result of the death of a very massive star.	b. constellation
3. The clouds of dust and gas that form stars are called.	c. Space
4. Various shapes appear when viewed from the ground. physical relationship with each other It is called a group of stars that do not exist.	d. black hole

In which option are the above expressions and concepts correctly matched?

A)

1	2	3	4
c	d	a	b

B)

1	2	3	4
c	a	b	d

C)

1	2	3	4
d	b	c	a

D)

1	2	3	4
c	d	b	a

27. Celestial bodies formed by the compression of high-temperature gas and dust particles are called..... Which of the following expressions should go in the blank space?

A) Planet B) Star
Tea D) Asteroid

28.

1. Stars outnumber planets in our solar system.

II. There is no relationship between the temperatures of stars and their luminosity.

III. Every star has a certain life span.

IV. Stars are natural light sources.

Which of the above given statements Is it true?

A) Well B) IV only C) II and III D) III and IV

29. Regarding the stars;

1. The hottest star is red in color.

Stars are masses of hot gas born from clouds of superheated gas and dust.

III. Stars have a five-pointed shape.

IV. A comet does not have star properties.

Which of the statements is/are correct?

A) II and III B) II and IV
C) I and III D) I, II and III, V

30. What distance unit should a student use to calculate the distance between the Milky Way galaxy and the Andromeda galaxy?

A) Meter B) Light year
C) Kilometer D) Farsah

31.

Examples of some celestial bodies are given in the boxes to the side. Which celestial body is not given as an example?

A) Nebula B) Constellation
C) Galaxy D) Planet

32. Regarding galaxies,

I. They may be spiral, elliptical or irregular in shape.

II. The Milky Way and Andromeda are examples of galaxies.

III. They are galaxies consisting of stars and celestial bodies.

Which of the following is correct?

A) Well B) I and III C) II and III D) I, II and III

33. The students asked Teacher Zeynep the following questions about space and the universe:

Ali: Is the Sun the largest known celestial body?

Ayşe: Is space the part of the universe outside the Earth?

Ahmet: Can the Universe Earth + Space equation be established?

Accordingly, to which students' questions did Teacher Zeynep answer "No"?

A) Only Ali B) Only Ahmet
C) Ayşe and Ahmet D) Ali, Ayşe and Ahmet

34.

Students' thoughts about constellations are given above.

Accordingly, which of the following is true?

A) All three students' opinions are correct.

B) Enes's opinion is wrong, Görkem and Büşra's opinion is wrong It is true.

C) Büşra's opinion is wrong, Görkem and Enes' opinion is wrong It is true.

D) All three students' ideas are wrong.

35.

Teacher:.....?

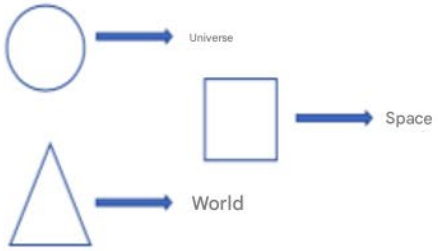
Student: It is the structure that includes the Earth, the Solar System, the Moon and many stars.

The student answered the teacher's question as above.

According to the student's answer, which of the following options is the teacher's question?

A) What is a planet? B) What is a meteor?
C) What is a galaxy? D) What is a comet?

36.



Mehmet expressed some concepts related to space with geometric symbols as above.

When Mehmet shows these symbols as in which of the following, he correctly orders the concepts according to their size?

APPENDIX B: SCALE OF INTEREST IN ASTRONOMY (QUANTITATIVE DATA SOURCE-2)

Description: This scale will be used to measure your interest in astronomy. Your evaluations will make significant contributions to the research. Please answer sincerely. Thanks for your participation. Please cross the box 5 if you strongly agree, 4 if you agree, 3 if you are undecided, 2 if you disagree, and 1 if you strongly disagree.

Table B1. Interest in astronomy

QUESTIONS	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
	1	2	3	4	5
1 I research the answers to questions I wonder about related to the universe.					
2 The idea of traveling to a planet outside Earth excites me.					
3 I would like to conduct investigations in a major research center such as CERN.					
4 I am interested in sky photography.					
5 I like the idea of creating an online platform where space-related project ideas are discussed.					
6 I wonder what it feels like to work at NASA.					
7 I would like to study in the field of space sciences and astronomy.					
8 I enjoy reading articles/books/journals to learn more about stars and planets.					
9 I would like to visit observatories.					
10 I would like to participate in applied astronomy workshops.					
11 I would like to visit planetariums to learn about planets and stars.					
12 I follow research that aims to find traces of life beyond Earth.					
13 I would like to travel to space.					
14 I am interested in scientific studies on astronomy and space published in academic journals.					
15 I look for opportunities to participate in sky-watching events.					
16 I am curious about living conditions on space stations.					
17 I would like to become an astronomer.					
18 I am curious about the scientific studies conducted on space stations.					
19 I would like to meet experts in astronomy and space sciences in interactive environments.					
20 I would like to pursue a profession related to astronomy.					
21 Learning astronomy concepts is enjoyable.					
22 I wonder what kind of scientific studies are conducted at NASA.					
23 I enjoy watching documentary programs on astronomy and space studies.					
24 I am interested in social media accounts followed by people who dream about space.					
25 I closely follow current research on astronomy.					
26 I am curious about how rockets work.					
27 I wonder about the daily lives of astronauts in space.					
28 I enjoy using sky-observation programs such as SkyView or Stellarium.					
29 I watch news about possible life on exoplanets.					
30 I am interested in the work that astronomers do.					
31 I am curious about how astronauts prepare for space missions.					

APPENDIX C: OPEN-ENDED QUESTIONS (QUALITATIVE DATA SOURCES)

AN OBJECT IS APPROACHING – WEEK 1

"A large meteorite is approaching Earth, and there is not much time left to stop it. If this meteorite hits Earth, life on the planet will end. How would you prevent this meteorite from hitting Earth?"

QUESTION 1: The film shows that a meteorite is rapidly approaching Earth. If you were part of NASA's team, what solution would you propose?

QUESTION 2: We see that they had no prior plan for such extraterrestrial threats and were caught unprepared. Are we prepared in real life? Are there existing projects developed for this? Have you ever heard of such a project?

QUESTION 3: In the film, we see two different teams. How do you think their paths will intersect? Any predictions? :)

QUESTION 4: They mention that they will land on a soft surface of the asteroid. How might they have identified this soft-landing area?

QUESTION 5: We see some tests being conducted on the drilling crew. Why do you think these tests are done? Do astronauts undergo similar tests in real life?

AN OBJECT IS APPROACHING – WEEK 2

QUESTION 1: Why might the gravitational pull on the meteorite be as low as that of the Moon?

QUESTION 2: During fuel transfer, a leak occurred and pressure increased. What solution would you propose in such a situation?

QUESTION 3: Landing on an iron field caused them to lose connection. What might be the main reason for this? What is the role of iron here?

QUESTION 4: You survived a space accident alone. What steps would you take to stay alive and be rescued?

QUESTION 5: The U.S. president is expected to make a decision. What decision was made? What would you decide if you were in that position?

AN OBJECT IS APPROACHING – WEEK 3

QUESTION 1: While the other team came for help, they hit a rock and were damaged; their thrusters failed, and they began to ascend. Why did they need thrusters to descend?

QUESTION 2: During the second attempt, they encountered a gas pocket, shaking began, and the explosion failed. What could this gas pocket be, and how might it have become an advantage?

QUESTION 3: The bomb's remote control malfunctioned. What decision would you make in such a moment?

QUESTION 4: You drew the short straw — what decision would you make?

QUESTION 5: The igniters did not work at launch. How would you solve this problem?

QUESTION 6: The meteorite was rapidly approaching Earth. Why didn't they feel the movement of the meteorite when they landed on it?