Innovative Technologies in Science Education and New Approaches in Technology

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Introduction

Technology is seen as an indispensable part of our life in this period which we call digital age. In addition, new generation students, who are called digital natives in many national and international reports, are expected to be information technology literate during their educational life and for job opportunities in future life, and this is considered to be an important quality for them (Hills et al., 2016). Accordingly, knowing and using the technology is thought to be important.

During this era, technology is seen as a discipline that people designed by using science (Simon, 1983). Technology is also considered as a tool that can be used in different areas and play an important role in facilitating the work of individuals (Saettler, 1968). In addition to this, the integration of technology, which can be used in almost every area, into the education also comes to the agenda and in this regard, efforts are made in the educational policies of the countries. Within the scope of these efforts, the technologies used in education from past to present are discussed, they are updated with innovative technologies and included in the education process. Accordingly, contemporary and innovative technologies can be included in the curriculum and students are offered the opportunity to be intertwined with technology. Meanwhile, with the inclusion of technology in all areas of our lives, new and effective approaches are preferred in education. Adopting innovative and effective approaches for learning and teaching processes of the new generation, which is born into and growing in the digital age, is of great importance for the efficiency of education. Therefore, today's teachers are recommended to use innovative technologies in their classes in order to provide a better and effective education to new generation/digital individuals. In this sense, technology is used as a teaching tool and can play an auxiliary role in teaching, especially in areas like science where technology is considered to adapt easily (Commission on Instructional Technology, 1970).

In science education, various technologies have been used from past to present, including computer, projection, simulation, web 2.0 tools, 3-D printers, virtual laboratories and recently augmented reality, virtual reality, and digital hologram. These technologies are integrated into education programs as teaching tools in order to increase the efficiency

of the education. At the same time, the individuals who have the grasp of the technology are trained to meet the needs of the technology age. Especially the augmented reality, virtual reality and digital hologram technologies, which are frequently mentioned recently and have been used in different areas before, are considered important in terms of the up-to-dateness of education and it is considered to be the key part of education-technology integration. Considering the advantages that augmented reality, virtual reality and digital hologram technologies, which are called innovative technologies today, bring to the education process, these technologies should be included in education and accordingly the desired efficiency is expected to be obtained from education. In this context, innovative technologies can provide the users with the opportunity to make 3-D observations and materializing abstract concepts through 3-D images, which can provide a great advantage to students and teachers, especially in subjects that are difficult to understand in science education. In addition, innovative technologies have several advantages such as enriching learning environments, contributing to students' imagination, saving time in the education and training process, being a simple and cheap source that every student can reach, increasing motivation for learning, thus they are expected to be compatible with education-technology integration (Chen & Wang, 2015; Huang, Chen & Chou, 2016; Squire & Jan, 2007). Therefore, technology is thought to be related to education and in this sense, education is seen as an area where technology can be used comfortably. At the same time, considering the advantages of technology-education integration in the long term, it may help in achieving the qualities such as contributing to the country's economy, preparing the ground for industrial development and having the potential of a developed countries.

"Digital Immigrants" and 21st Century Students

According to Prensky (2001), those born before 1980 are considered as digital immigrants, and those born after 1980 are considered as digital natives. Digital natives are individuals who are born into technology and who are growing up in an environment dominated by technology. Recent studies show that this generation, called digital natives, can use information technologies at a much better level than their parents and teachers (Fritsch, 2010). Teachers of digital natives are digital immigrants. Depending on the period, problems are observed between teachers (digital immigrants) and learners (digital natives) in terms of competencies in using information communication technologies (Cukurbasi & Isman, 2014; Ransdell, Kent, Gaillard-Keney & Long 2011, Waycott, Bennett & Kennedy, 2010). In this context, digital classrooms come into play and they can meet the mentioned digital individuals at the same point. The digital classroom is a learning environment equipped with technology infrastructure (Roberts, 2007). Teachers have an important role in the transformation of classrooms into digital classrooms and bringing new technologies into the classroom settings. At the same time, the teachers

who will be in contact with 21st century students are expected to have sufficient technological knowledge at least as much as students. In this context, the definitions such as net generation, millennium generation, digital natives, multitasking generation, digital generation, and internet generation support this fact (Corlett, Sharples, Bull & Chan, 2005).

In parallel with the rapid developments in technology, the search for learning environments that will give 21st century learner skills continues at full speed. The new technologies are expected to improve teaching-learning processes (Corlett, Sharples, Bull & Chan, 2005).

ISTE Standards for Teachers

In 2008, the International Society for Technology in Education-(ISTE) published a series of forward-looking standards for teachers to support students' learning and creative thinking, design digital age activities and assessments, model digital studies, promote digital citizenship, modelling and engage in professional growth and leadership (Trust, 2018). ISTE standards for teachers are the standards describing technology use competencies of teachers. These standards include sub-categories such as learner, leader, citizen, collaborator, designer, facilitator, and analyst. The mentioned standards are expected to encourage collaboration with peers, deepen the practices, and guide students in their own learning by rethinking traditional approaches (ISTE, 2020). In addition, these standards cover the areas of competence such as the design of learning environments suitable for digital age, the work in digital age and being a model for learning (Trust, 2018). Institutions used ISTE standards to initiate the reform of the teacher education programs (Bucci, Cherup, Cunningham & Petrosino, 2003). Later, the use of these standards became widespread (Wiebe & Taylor, 1997).

Eight key competence area has been specified within Turkish Qualifications Framework (TQF), namely "communication in the mother tongue, communication in foreign languages, mathematical competence and core competences in science/technology, digital competence, learning to learn, social and civic competences, sense of initiative and entrepreneurship, cultural awareness and expression" (MoNE, 2018). The review of these skills reveals the emphasis put on science and technology skills. Especially mathematical competence, core competences in science/technology and digital competence cover the use of information and communication technologies in daily life. On the other hand, 21st century skills, are considered under three categories and they include learning and innovation skills, life and career awareness, and information media and technology skills. Information, media and technology skills are also prominent in 21st century skills (Partnership for 21st Century Skills, 2013). The skill of using information and communication technologies effectively is reported as one of the basic skills of 21st century skills (Voogt & Roblin, 2010).

Individuals who have information literacy, media literacy and information communication technology literacy skills are assumed to be able to acquire 21st century technology skills. In this sense, the concept of literacy should be perceived as individuals having the ability to live by working in a technological world and being able to acquire technology-based skills (Panel, 2002). NCREL (2003) has defined 21st century skills that must be acquired by the next generation to overcome the challenges of globalization arising from the advancement of knowledge and technology. There are four main areas mentioned in 21st century skills: digital age literacy, creative thinking, effective communication and high efficiency. The digital age literacy skills that comply with NCREL (2003) are basic literacy, scientific literacy, economic literacy, technological literacy, visual literacy, information literacy and multicultural literacy (Kamisah & Neelavany, 2010).

Science Education and Educational Technologies from Past to Present

Science education is one of the areas that can easily adapt to technology and the reflections of technology are frequently encountered in science education. The reason for this harmony between technology and science education is; the students consider science course as a course difficult to understand, abstract concepts are quite common in science education, and biology-based topics such as cells, systems and organs, DNA and genetic code require 3-D examinations. Accordingly, in order to eliminate the mentioned reasons or to reduce their effects, different technological equipment is employed in science classes, trying to break students' prejudices about the science course. At the same time, various technologies can be used to make science education enjoyable and to increase motivation towards the course.

Technologies used in science education varied from past to present, depending on the development of technology. Computers, which we saw in classroom settings years ago, which was forming one of the first steps of education-technology integration, are considered quite ordinary today. In the following years, considering the advantage of computers in education, the projectors took their place in the classroom settings. These were followed by various technologies such as simulations, 3-D printers, web 2.0 tools, industry 4.0 tools, and virtual laboratories that are used in the field of education. Today, the efforts are made to ensure that these technologies are updated and placed in classroom settings, and at the same time, it is aimed to bring a different perspective to education by utilizing 21st century technologies. In this context, 21st century technologies are called as innovative technologies and several studies are carried out to bring them into classroom settings. Innovative technologies such as augmented reality, virtual reality, and digital hologram are employed in the 21st century, especially in the teaching of subjects and concepts included in science education. In our country, the emphasis put on digitalization and technological competencies in the recent science curriculum also supports the infrastructure of the use of innovative technologies in the classroom setting.

Digital competence and technological competence sub-dimensions, which are included within the framework of the basic competences of the science curriculum updated in 2018, also emphasize students' technological knowledge and skills and set the training of technology using individuals as an objective. In this context, the education system can change according to the development of technology and technology-education integration can be provided on education policies as well.

Innovative Technologies in 21st Century Science Education

With the 21st century, the concept of innovative technologies has emerged, and the newest products of technology were put under this concept. Augmented reality, virtual reality and digital holograms are the innovative technologies that are frequently mentioned in our age. These technologies, which have been previously used in many different sectors such as art, architecture, tourism, health, attract attention with their integration into education. They can be used in science education especially for the topics that are difficult to understand, and that require 3-D examination.

A study, which examined the updated current science curriculum in Turkey in terms of innovative technologies, has reported that the following units are suitable for the use of innovative technological applications; 5th grade - Sun, Earth and Moon, the world of livings, humans and environment; 6th grade - Solar system and eclipses, matter and heat, the systems in our body and health; 7th grade - Solar System and beyond, cell and divisions; and 8th grade- DNA and genetic code, pressure (Seckin-Kapucu, 2020).

Augmented Reality

Augmented reality, which is one of the innovative technologies, is considered as the technology that can create a realistic simulation and experimental environment for its users and offer the opportunity to make observation in this environment (Azuma, 1997). At the same time, augmented reality technology is seen as the enrichment of the environment by imaging the real world with cameras or wearable technologies. Thanks to this technology, users can experience the feeling of real-like environment and take part in this environment (Azuma, 1997; Milgram & Kishino, 1994).

Azuma (1997) emphasizes three features of augmented reality; combining reality and virtuality, enabling simultaneous interaction and containing 3-D objects. Milgram and Kishino (1994) describe the transition between reality and virtual environment in the diagram called "Reality-Virtuality Continuum" (Figure 1).

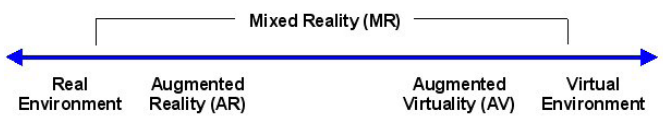

Figure 1. Reality Virtuality Continuum (Milgram & Kishino, 1994)

The development of augmented reality applications takes place in four steps: determining the marker, pretreatment, triggering the application and running the application (Abdusselam, 2016). At the same time, the use of augmented reality applications in and out of the classroom became very common in recent years. Enriched books used by students can be shown as the first example of augmented reality applications in schools (Abdusselam, 2016). Moreover, there are many augmented reality applications that can be used in mobile and desktop technological devices, that students can access easily and free of charge. Of these, LearnAR, ZooBurst, BuildAR are desktop applications while Aurasma, Anatomy 4D, Spacecraft3D, Quiver - 3D ColoringApp, Zoo-AR, Fetch! LunchRush, Fectar are mobile applications (Perez-Lopez & Contero, 2013). Images of some of the augmented reality applications that can be accessed easily and free of charge (Figure 2-3) are shown below.

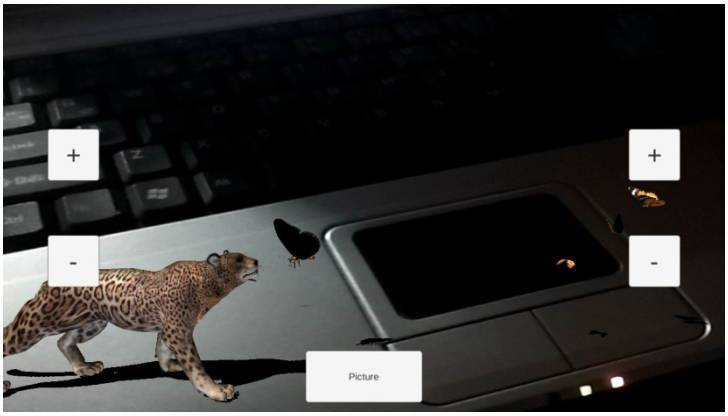

Figure 2. Zoo-AR Application
(Android Link: https://play.google.com/store/apps/details?id=com.wellinic.arshow)

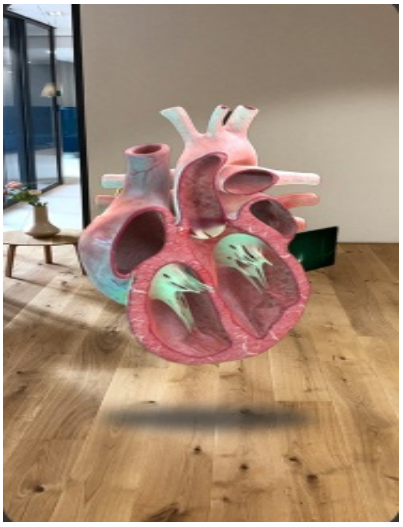

Figure 3. Fectar Application
(Android Link: https://play.google.com/store/apps/details?id=io.spoton.viewer)

Virtual Reality

Virtual reality is another innovative technology that is similar to augmented reality.

Virtual reality can be defined as a completely virtual and digital setting, created by using computer hardware or software to give the feeling of a real-like environment to the users and to provide the image of the relevant setting (Kipper & Rampolla, 2013). At the same time, virtual reality applications are thought to make scientific knowledge existing in nature more understandable (Yair, 2001). Therefore, virtual reality technology is considered to be compatible with education integration and it will contribute to the education-training process. Virtual reality applications, which can be used especially in astronomy topicas in science class, can also provide different advantages to its users. Students who do not have the opportunity to have a telescope for sky investigations can examine 3-D images on topics such as sky observations, space exploration, the solar system and planets, stars and constellations via virtual reality applications and they can observe real-like digital images of the sky objects. There are many different virtual reality applications that students and teachers can easily access. Some of these applications are; Solar systemscope is Skyview, Solar walk 2, Stellarium, NASA, Google SkyMap, Celestia, Redshift-Astronomy, Earth viewer, Star chart, ISS detector, Sky Guide AR, Sky Safari 6, Star walk 2. These applications can be accessed free of charge from mobile devices stores. Some examples of virtual reality mobile applications are shown below (Figure 4-5).

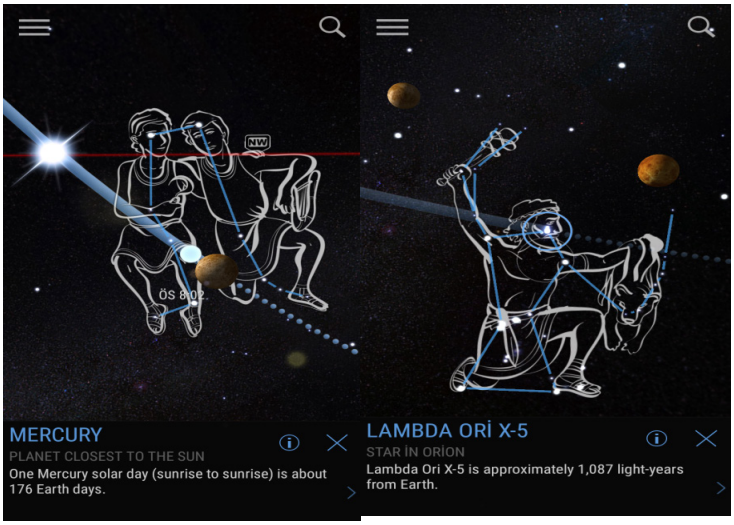

Figure 4. SkyView Application
(Android Link: https://play.google.com/store/apps/details?id=com.t11.skyviewfree)

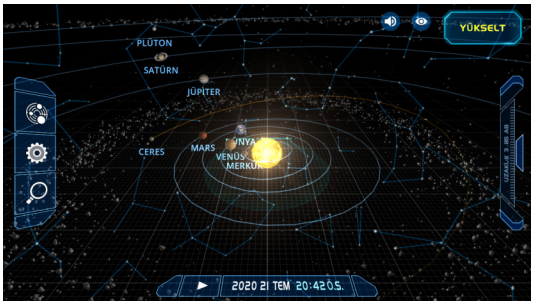

Figure 5. Solar System Scope Application
(Android Link: https://play.google.com/store/apps/details?id=air.com.eu.inove.sss2)

Digital Hologram

Hologram is defined as a tool that can transfer 3-D images of the selected objects to different locations and ensure the continuity of the images even in the absence of these objects (Katsioloudis & Jones, 2018). In this way, thanks to the holograms, 3-D images of the objects that are not present in the setting and that are subject to examination can be accessed. Holograms that were used in areas such as architecture, tourism and entertainment, medicine, industry have recently been started to be used in the field of education as well (Rahim, Abdullasim, Saifudin & Omar, 2018; Turk, 2020). It is especially used in the teaching of subjects and concepts that are difficult to understand in science education and is also preferred as a teaching tool in the materialization of abstract concepts and subjects. Digital holograms can be prepared as videos in programs such as Powerpoint or Camtasia and images can be created with hologram pyramids (Turk, Turk & Seckin-Kapucu, 2020). In science education the use of hologram is preferred in the topics requiring a microscope to observe, such as cells, genes and chromosomes. The image of chromosome described in the DNA and genetic code unit of science education is shown below.

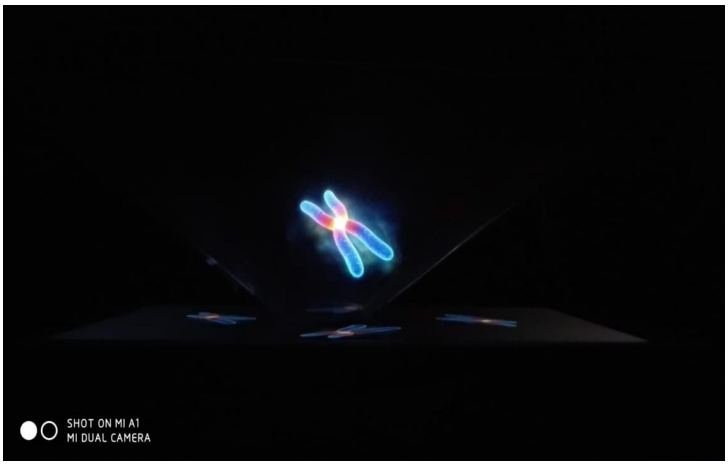

Figure 5. Hologram Image of a Chromosome (Turk, 2020).

Advantages of Innovative Technologies to Education

The introduction of innovative technologies into our lives in 21st century and their integration into education as well as in different areas such as health, art, medicine, tourism and industry have brought many advantages. Accordingly, the use of innovative technologies in education enriches learning environments and helps to prepare the appropriate infrastructure for different learning activities. In addition, they are effective in saving time allocated for teaching and learning and they can be easily used as textbooks as they can be moved easily into the classroom settings (Cakıroglu, Gokoglu & Cebi, 2015; Kol, 2012).

The use of augmented reality and virtual reality, which are among 21st century technologies,

in education, especially in science education, draws attention with the advantages it provides to students and teachers. With the 3-D images created by these technologies, abstract concepts can be materialized and student prejudices for difficult-to-understand topics can be broken. At the same time, as these technologies appeal to more than one sensory organ, different types of intelligence existing in students can be revealed and the efficiency of the education can increase. In addition, augmented and virtual reality technologies that provide the opportunity to have fun in the lessons, are the technologies that provide easy access for the teachers. This fact also provides an advantage to bring virtual reality technologies into the classroom setting easily (Chang, Hou, Pan, Sung & Chang, 2015; Huang, Chen & Chou, 2016; Lin, Duh, Li, Wang & Tsai, 2013). .

Digital holograms, which are frequently mentioned today, and we see the examples in education, still remains up to date in the education world with the advantages they provide. Digital holograms provide the opportunity to create the images of objects that are not present in the setting, allow to examine them in the absence of the tools such as microscopes or telescopes, and give the opportunity to observe 3-D images of the objects, such as extinct creatures, which are considered as significant advantages (Kalansooriya, Marasinghe & Bandara, 2015). Also, the advantages of digital holograms in the long term are; contributing to the country's economy and industry, strengthening the country's economy by creating a technology market and technology industry, allowing the development of the industrial infrastructure with innovative technologies in education, and creating a different perspective to education through innovative teaching methods and techniques (Mavrikios et al., 2019).

Literature Review

The scanning of the web of science database for "innovative technology" keyword showed that the studies under this title are mostly in America, China, Spain, Russia and England. These studies were found to be written in English, Spanish, Russian, Chinese and Portuguese, respectively. The highest number of studies on this topic was conducted in 2017, followed by 2018, 2016, 2015 and 2019. There are mostly conference papers on this subject, followed by articles, book chapters, reviews, and early access studies. The author named HWANG GJ was the author with the highest number of works on this subject, followed by CHU HC, HUSANU INC. The studies on innovative technologies were observed to concentrate in areas such as education, computer science, engineering, social sciences, business economics, psychology, library science, linguistics and communication. Accordingly, the studies on the use of innovative technologies in education and especially in science education was observed to increase since the beginning of 2000s.

In their study, Chen, Chi, Hung, and Kang (2011) concluded that the use of technology

in education offers students the opportunity to actively participate in the lessons, and that permanent and meaningful learning is provided. Ma, Gu and Wang (2014) showed that the use of technology in education has many advantages and emphasized that one of the advantages is practicality.

In their study, Cheung and Hew (2009) emphasized that the use of technology and the advantages it provides are the reasons of preferring technology in education. Similarly, Ryu and Parsons (2012) suggested that the reason of the use of technology in education is the advantage of increasing learning.

There are many research findings showing that AR, which is one of the innovative technologies, helps to materialize abstract concepts (Chang et al., 2015; Huang, Chen, & Chou, 2016; Lin et al., 2013; Sommerauer & Müller, 2014; Tsai et al., 2013). Chen (2006) showed that using AR, students understand chemical structures better than textbooks. In the study of Sin and Zaman (2010), students learned the characteristics of the solar system using a textbook or AR. Wojciechowski and Cellary (2013) concluded that with the use of augmented reality applications in education, learners are motivated for learning and that their learning graphics are improved. In addition, Singhal, Bagga, Goyal, and Saxena (2012) concluded that augmented reality technologies improve students' research skills and also the interaction between teacher and student is positively affected. In the study conducted by Abdusselam and Karal (2012), the augmented reality practices were found to motivate students' participation in activities, increase their interest in the lesson, and they were eagerly involved in the classes.

Regarding the studies on teaching astronomy concepts in science education, virtual reality programs were reported to be effective (Barron & Orwig, 1997; Chen, Yang, Shen, & Jeng, 2007; Diakidoy & Kendeou, 2001; Trundle & Bell, 2010).

The review of the literature on innovative technologies revealed that the studies in this area have increased especially in recent years and the use of innovative technologies in education has been discussed in terms of different aspects. Sheet et al. (2014) have examined the examples of the use of holograms, which is one of the innovative technologies, in education, and concluded that this technology should be used in education, and since it is easy to access and low cost, it may be one of the most frequently used technologies in the future. Orcos and Magrenan (2018) used hologram technology to teach cells and divisions in science education and consequently, they concluded that digital holograms should be used as a teaching tool to increase students' motivation and students' satisfaction level towards the hologram is high.

In their study, Yamaguchi and Yoshikawa (2012) revealed that holograms are effective in students' concrete learning. As a result of the School and Unver's (2016) research that aimed to support teacher candidates' thinking and problem-solving skills through

holograms, teacher candidates' astronomy knowledge was found to be increased with the products they created in the field of astronomy.

In their literature review about the use of technology and hologram technology in education, Ramachandiran, Chong and Subramanian (2019) concluded that educational technologies have a significant role in increasing learning curves of 21st century learners.

Conclusion

Of late years, lifelong learning individuals are needed. These individuals are expected to learn how to learn in every setting and to take responsibility of their own learning. Thanks to information and communication technologies, individuals can access information in anywhere and at any time. Therefore, learning can take place not only in formal but also in informal settings, which offer individuals a variety of learning environments. Informal learning environments include houses, streets and playgrounds, other settings (museums, botanical gardens, planetariums, etc.), mobile technologies, web. 2.0 applications and e-learning areas (Turk & Seckin-Kapucu, 2020). Technologic equipment that support informal learning process include mobile technologies, web. 2.0 applications and e-learning areas. The technologies considered as 21st century technologies and called innovative technologies can take place in both formal and informal educational settings. Hence, lifelong education can be provided anywhere, and the efficiency of the education can be increased. At the same time each individual can easily access the mentioned technologies and the ease of use of these technologies contributes to learn using technology in almost every area. This fact also provides advantages for the education and training processes of the countries in the long term and the reflection of these advantages on education is of great importance for the students of today, who are the individuals of the future. In addition, technological competence, which is one of the requirements of our age, can be acquired through educational programs adopted by countries, having the required technological equipment. In this way, the individuals who will have no problems in technology in the future, who have the ability to use technology and who have a grasp of technology, are raised. This is also seen as an indicator of the development level of countries. Developed countries raise well-equipped individuals, individuals who can keep up with the advancing technology can easily benefit from the job opportunities and individuals who have technological competence are employed in almost every area because of the active use of technology, which support this idea. Therefore, technology is considered to have an important role in both formal and informal education and technology literate individuals should be trained. In this context, technology-supported projects and training programs should be conducted, hence the integration of individuals with technology should be ensured. Science education includes many topics, in which technology can be used, and it is necessary to provide an innovative perspective to this course, where students are biased, by taking the advantage of technology's ease of

learning. In this way, the link between science and technology can be strengthened and innovative approaches in science and technology can be developed.

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