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INNOVATIVE APPROACHES IN SCIENCE EDUCATION

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Editor

ASSOC. PROF. GÜLDEN GÜRSOY

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Innovative Approaches in Science Education

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FOREWORD

Large-scale disease outbreaks in history not only caused fear and panic, but also led to radical transformations in all dimensions of social life. It is observed that the COVID-19 pandemic, which we are facing today, has led to new ideas and structuring in all fields from politics to art, from economy to education. With the onset of the pandemic process, many educational institutions at all levels have closed their doors indefinitely, and approximately one and a half billion students from all age groups have transitioned from face-to-face education to emergency distance education activities. In this book, the methods that can be used during the emergency distance education are especially included. Specific to science education, the content of the methods was tried to be explained with the support of the studies in the literature, and examples of activities were prepared for conducting an effective face-to-face or online science course. In addition, care has been taken to use a fluent language so that the reader can read with pleasure.

This eight-chapter book contains these titles: First chapter *Social media as an educational platform during COVID-19 pandemic: A general overview*; the second chapter *Project-based virtual learning in science education*; the third chapter *Authentic learning in science education*; the fourth chapter *Digital storytelling in science education*; the fifth chapter *A new environmental education approach: Environmental emotion-enhanced activities*; the sixth chapter *Mobile learning in science education*; the seventh chapter *Learning and teaching skills in 21st century*; and lastly the eighth chapter *The significance of the nature of science in science education.*

The book is intended to be a reference for educators, researchers, teachers, pre-service teachers and policy makers. It aims to bring together scientists who carry out new and current studies and research in this field and to shed light on possible future scientific discussions and research.

I would like to thank our esteemed authors, respectable referees, and the staff of Livre de Lyon Publishing House, who contributed to the creation of this book.

August

Assoc. Prof. Gülden GÜRSOY
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CHAPTER 1

SOCIAL MEDIA AS AN EDUCATIONAL PLATFORM DURING COVID-19 PANDEMIC: A GENERAL OVERVIEW

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1. Introduction

The increasing need for internet-based communication technologies during the Covid-19 pandemic crisis requires to choose appropriate online platforms to interact and communicate effectively and quickly with stakeholders affected by the crisis (Cerci, Canoz, & Canoz, 2020). The education systems are one of the most affected areas by this serious health crisis (Crawford, et. al., 2020). Due to the compelling effects of this pandemic disruption to global education, importance of the online platforms increased from counseling services to remote teaching and learning (Maqsood, Abbas, Rehman & Mubeen, 2020).

With the rapid development of Web 2.0 technologies, it has transformed online networks into interactive social platforms where users can generate and share visual or audio contents (Bozkurt, Karadeniz, & Koçdar, 2017). Social Network Sites (SNSs) are among the latest Web 2.0 tools that provide an online platform for people to create a public or private identity and share their experiences, likings, or activities through visual or written messages and become members of groups (Boyd & Ellison, 2008; Karakoyun, 2019). In the Covid-19 pandemic period when social or physical distance rules must be followed, SNSs provide people online platform for many interpersonal interaction and communication needs (Greenhow, & Chapman, 2020). Most teens and young adults use SNSs, such as Facebook, Myspace, YouTube, Weblogs, Xanga, Friendster, Orkut, Bebo, and Wiki, to socialize and communicate with others (Kayri & Cakir, 2010; Singh, 2013). According to the statistical data of the study conducted for the '*Pew Internet and American Life Project'*, approximately 93% of 18-29 years old young adults reported going online, with 72% them being active on at least one SNSs in 2009 (Lenhart, Purcell, Smith, & Zickuhr, 2010). Moreover, it has been reported in many recent studies that these rates increased during Covid-19 pandemic period (e.g., Drouin et. al. 2020).

These social technological capabilities have rapidly transformed not only the communication manner among people but also the mediation of teaching and learning environments (Havick, 2000; Singh, 2013). Within

this context, the educators had to settle effective and imaginative distance education environments for maximizing student engagement and online counselling in Covid-19 pandemic crisis (Danjou, 2020; Dutta, 2020; Rose et. al. 2019; Rau et. al. 2017; Supriyanto, et. al. 2020). As such, this chapter addresses an area in the literature about the pros and cons of using SNSs in at-home education, especially in Covid-19 pandemic. For this, the relevant literature has been discussed under two subheadings as presented below.

2. Psychosocial Dimensions of SNSs Use in Covid-19 Pandemic

Social networks provide suitable platforms for people to share information, seek social or academic support, and express anxieties relating traumatic events (Cumiskey & Hjorth, 2019; Westerman, Spence, Van Der Heide, 2014). Rodríguez Hidalgo, Tan, and Verlegh, (2015), analyzed the formation of social sharing in 540 blog posts in a SNS (Live Journal). They determined different types of online Social Sharing of Emotion (SSE) and put forwarded a theoretical model of online SSE. According to Rodríguez Hidalgo, et. al. (2015) SSE happens when someone shares an emotional experience with another and is considered possibly helpful. They found that online social sharing process in Live Journal, looks like face-to-face SSE in many ways.

Ellison, Steinfield, and Lampe, (2007) addressed the relationship between college students' use of SNSs and psychosocial outcomes. They found that there was a positive relationship between Facebook use and building and providing social capital which refers to "*the resources accumulated through the relationships among people*" In another study, Ellison, Steinfield, and Lampe (2011) expanded their previous research and revealed that involving in social information sharing or gathering behaviors on Facebook was related to increased social capital. Mazer, Murphy, & Simonds, (2007) found that students who experienced teacher self-disclosure on Facebook had a higher level of motivation for learning. In another study examining the relationship between social media usages and personality traits, Karakoyun (2019) was aimed to examine preservice teachers' social network use purposes with respect to their personality traits. He found that some personality traits like conscientiousness, openness to experience and negative valence were predictors of the sub-factors of social network use purposes. Thus, it becomes clear that further studies are needed to encourage the conscious use of SNS rather than addictive use.

In this line, many studies echoed that when professional guidance and orientation is not given for the purposes of SNSs, it can affect psychosocial problems and internet addiction or affected by them (Gómez-Galán, Martínez-López, Lázaro-Pérez, & Sánchez-Serrano, 2020, Hamutoglu, Topal, & Gezgin, 2020). According to Gómez-Galán, et. al.

(2020) SNSs addiction can be the result of depression, anxiety, and harassment and affect academic performance. For example, Müller et.al. (2016) investigated whether using social networks is related to internet addiction symptoms and psychosocial distress. They also explored which variables (demography, personality) predict addictive use. According to the findings, gender appears to be an important factor in the relationship between the frequency of social media use and internet addiction criteria (4.1% boys, 3.6% girls), especially regarding preoccupation and loss of control. They concluded that the frequency of social media use might be considered as another form of addictive online behavior and can be related to addictive symptoms and is accompanied by psychosocial distress. Similarly, in a study (Özgür, 2013) with pre-service teachers, the relationship between interaction anxiousness and social networking addiction was high level, and the relationship between the level of loneliness and social networking addiction was found at a mid-level. Gómez-Galán, et. al. (2020) examined the effects of COVID-19 pandemic on internet and SNSs addiction of the students from 14 Spanish universities. They detected a high social media usage with significant behaviors of addiction and argued that there should be preventive guidance and counseling services in university programs to redirect these addictive behaviors and minimize negative impacts.

In another study, Drouin et. al. (2020) showed that both parents and their especially teenage children had increased technology and social media use during Covid-19 pandemic. They also found a direct correlation between the level of technology/social media use and anxiety levels of the parents and children. The level of seeking information and social support from social media was also higher among parents with higher anxiety. In conclusion, the potential of SNSs to express and quell anxiety through social support or incite anxiety through erroneous information became especially important during this health crisis period. In a recent study, Shawna et. al. (2021) reported parent-child dynamics related school closures in the first phase of the COVID-19 pandemic (April 2020). The findings revealed that there was a positive correlation between parents' stress scores and child anxiety scores. Shawna et. al. (2021) found that parenting stress related to at-home teaching were significantly negatively associated with parents' perceptions of readiness for homeschooling. Therefore, relevant literature echoed that students should be given appropriate guidance and counseling services to reduce the overuse of social networks at a level leading to addiction.

3. Educational Use of SNSs

As briefly mentioned above, since the use of SNSs has rapidly increased in the present crisis than usual (Wong, et. al., 2020) utilizing potentiality of these internet-based social technologies as education platforms that complement face-to-face courses has become highly popular in educational institutions (Maqsood, et. al., 2020). Researchers have reported the contribution of the online platforms to the teaching and learning process stemming from the fact that they have produced a more flexible and alternative teaching and learning platform in education (Concannon, Flynn, & Campbell, 2005; Ekoç, 2014; Hung, et. al., 2010; Lim & Ismail, 2010; McCarthy, 2012; Pattanapichet & Wichadee, 2015).

In most countries around the World, distance education tools were employed because of Face-to-face education has unexpectedly been interrupted during Covid-19 pandemic (Daniel, 2020; Hark Söylemez, 2020). Due to the too much use of social media in communication in today's societies (Cerci, et. al. 2020), many educators have sought how to utilize social networks potential in order to build common understanding, provide emotional support, and develop their distance pedagogies (Rodríguez-Hoyos, Haya, & Fernández-Díaz, 2015; Staudt Willet, 2019; Trust, Carpenter, Krutka, & Kimmons, 2020; Ogedebe, Emmanuel, & Musa, 2012; Tutgun-Ünal & Köroğlu, 2013; Wichadee, 2013). For instance, McCann (2009), SNSs allow students to build virtual learning communities which enable students to communicate, interact, and collaborate on online spaces.

SNSs (e.g. Twitter, Facebook, Instagram, WhatsApp, Messanger, Pinterest, Telegram, Snapchat) provide many opportunities in crisis communication such as creating and sharing information, ability to communicate interactively with groups or individuals directly (Cerci, et. al. 2020). According to many studies, SNSs provides useful and robust platforms for hosting and sharing asynchronous teaching videos that is accessible 24/7 (Alden, 2017; Danjou, 2020). In a meta-analysis study, Van Osch and Coursaris, (2015) analyzed 610 articles on SNSs and found that the most of these studies were related to education. Greenhow, and Chapman, (2020) summarized comprehensions about social media usage in K-12 education from literature reviews and recent case studies. They aimed to identify how SNSs can be used together with conventional education systems and emphasized three opportunities (*fostering active learning, community building and civic participation*) offered by SNSs.

Ekoç (2014) argued that communication by social media provides opportunities for learners to exchange information and engage in negotiation of meaning. Cerci et. al (2020) examined the use social media

in sharing and gathering information during the Covid-19 pandemic. They found that participants mostly prefer social media in getting and sharing information and to follow the agenda and receive news about the COVID-19 pandemic crisis. Danjou (2020) used the Facebook platform to share his asynchronous organic chemistry lecture videos to allow students learn at their own pace. Hark Söylemez, (2020) reviewed some studies on distance education in the context of Covid-19 pandemic. She found that most of the studies are mostly focused on revealing student ideas, evaluation of the situation, and carried out at the university level. She has also reported following results: Students are struggling to continue their education due to limited web accessibilities; to communicate with their instructors; lack of mutual interaction of student-student or teacher-student; issues in relation to maintaining motivation in online sessions. Trust et. al. (2020) investigated the educators' cognitive, social, and affective needs which were upset in the coronavirus pandemic. For this study, they examined the educators' tweets indicated two hashtags *"-#RemoteLearning and #RemoteTeaching*" that aimed to reveal affinity spaces for educators managing the work turmoil caused by the COVID-19 pandemic. They analyzed 10.444 tweets posted by 3,939 accounts with the word "teacher" in their user information. They conducted qualitative content analysis and sentiment analysis on the whole dataset of 10,444 tweets. The findings revealed that, educators turned to social media to interact with colleagues and generally share daily experiences, ideas, learning opportunities related to remote teaching, motivating messages during challenging circumstances, and resources for using specific technology tools or apps.

As asserted above, thanks to the opportunities provided by SNSs, teachers and students communicate comfortably, confidently, and flexibly with each other without the restrictions of time and space (Hung et al., 2010). That is, SNSs can create online learning communities and keep teachers and students connected in and out of the school. So, educational researchers realized that SNSs have a significant potential (Acun, 2020; Gerlich, Browning, & Westermann, 2010; Krutka, Nowell, & McMahon Whitlock, 2017; Tinmaz, 2012) and they have focused their attention on the relationship between students' social media usage and their performance or how they can engage or motivate the students to use SNSs for educational purposes (English & Duncan-Howell, 2008; Genç, 2010; Junco, 2011; Kayrı & Çakır, 2010; Ogedebe, et. al., 2012; Solmaz, 2018; Staines & Lauchs, 2013). For example, Ekoç (2014) evaluated the use of social media for educational purposes as an attempt to communicate with students outside of school settings, and argued that students' feeling of motivation can rise if they continually receive support or help in an online community. McCarthy (2012) studied with postgraduate and undergraduate students over one semester and reported the positive effects of Facebook use for e-mentoring. Keleş and Demirel (2011) found that

Facebook assisted course supported some educational aspects such as sharing and cooperation between students and lecturer, visualizing the course content in undergraduate education. Ogedebe et. al. (2012) found no substantial correlation between the amount of time a student spends on Facebook and her/his academic performance or participation in class.

Facebook which is one of the latest communication technologies, is quite popular also among the students, so such tools have a great potential to be used as an educational communication and collaboration means between teachers and learners (Roblyer, McDaniel, Webb, Herman & Witty, 2010). Junco (2012) examined the relationship between frequency of Facebook use, participation in Facebook activities, and student engagement. Results indicated that Facebook usage was significantly negatively predictive of engagement scores and positively predictive of time spent in co-curricular activities. On the other hand, Hew (2011) reviewed some studies about the use of Facebook by students and teachers and reported that since students use Facebook primarily to keep in touch with people they know, and therefore educational usage of Facebook is rare. They also concluded that research on SNSs in education was the beginning of its development, and therefore, it should be studied further.

In a review study, Rodríguez-Hoyos, et. al. (2015) analyzed 62 studies to discuss the latest research regarding SNSs in education. They found that most of the studies focused on the use of SNSs as educational tools in Higher Education. According to Gerlich et al. (2010) educational usage of social media should be promoted in college courses to deliver content and to engage students. Dutta (2020) aimed to examine effect of various digital social media platforms for dissemination of knowledge sources and to enlighten the effectiveness of online pedagogy, and its outcomes in Indian higher education. The findings showed that the popular SNSs (Instagram, Twitter, and Facebook) have been used by the university students in collecting academic information and provide online platforms for them to share experiences and create a common learning environment via discussing conceptions. Tutgun-Unal and Köroğlu (2013) analyzed prospective teachers' intended usage of SNSs and the level of adoption of social networks. They found that prospective teachers rate of educational use of social networks is quite high. Accordingly, Mazman and Koçak-Usluel (2010) reported that 50% of educational usage of Facebook could be explained by other functions along with the adoption processes of Facebook and Facebook adoption processes could explain 86% of all other functions. Correspondingly, Yaman and Yaman (2014) argued that social network websites can be used by university students for educational purposes effectively. Moreover, Hung, et al. (2010) found that higher grade college students demonstrated a significantly greater readiness in the

dimensions of self-guided reading, online communication self-efficacy, motivation for learning, and learner control compared to lower levels.

Many researchers also found that the attitude of the students towards educational use of social networks were very important (Genç, 2010; Kayrı & Çakır, 2010; Tutgun-Ünal & Köroğlu, 2013). For example, Tezer, Taşpolat, Kaya, and Sapanca, (2017) argued that preservice teachers' attitudes towards to SNSs had an influence on academic performance. Kayri and Çakır (2010) also studied the attitudes of the students towards educational use of Facebook and found that their views were heterogeneous. They suggested that SNSs could be used to provide continuity in lifelong learning. Genç (2010) pointed out that students have extremely positive thoughts about Facebook applications; they also adopted Facebook as a learning tool besides a communication tool. Similarly, Hung and Yuen's (2010) findings indicated that the bulk of participants developed strong beliefs of social connectedness and expressed favorable feelings regarding their learning experiences in the classes where social networking sites were utilized as a supplementary tool.

In conclusion, there exists a consensus that frequency and purpose of the students' use of SNSs affects their academic performance to some extent (Junco, 2011; Kayrı & Çakır, 2010). Additionally, SNSs can support educational activities in the remote teaching practices (English & Duncan-Howell, 2008). Moreover, such studies have generally concentrated on readdressing the ways in which teachers and students reimagine and construct the online learning environment (Greenhow, Sonnevend, & Agur, 2016). In this context, Mazman and Koçak-Usluel (2009) aimed to create a new model that could identify the influencing factors for the adoption of SNSs in education. In their proposed model, they specified four direct constructs affecting adoption process: *perceived usefulness, perceived ease of use, innovativeness, and social factors*. Therefore, SNSs should be considered as useful, innovative, ease to use and socially supportive by users to adopt them for usage in educational context.

4. Conclusion

The education community globally had challenge in both continuing formal education process and conducting guidance services during the Covid-19 pandemic crisis. In this global pandemic crisis online platforms can play a very important role in the continuation of education. In this challenge, educators and/or education researchers should pay more attention to the online information and communication sources and should channel these sources into education environments. Ensuring the continuation of formal education activities presuppose quickly adapting of educators, learners, and parents to this unexpected at-home

teaching period, which is an element of developing the professional competence of educators (Supriyanto et. al. 2020).

A large body of literature outlined above show that the use of SNSs can make students more flexible in sharing and gathering information or forwarding questions about any topic with peers or teachers during the at-home teaching process forced due to the pandemic crisis. Even though the literature reveals positive potentials of SNSs in at-home teaching, education researchers have also pointed out some challenges of using these social technologies. As concluded by Mehmood and Taswir, (2013), students' usage levels and/or purposes of SNSs or other social networks is an important factor that can affect academic performance positively or negatively. Therefore, educators should take several steps to ease the challenges through orientation trainings to concentrate the attention of students and to increase the duration of SNSs use in educational purposes.

Taken in this context, SNSs can create various opportunities and benefits for at-home education provided that the students and teachers are guided correctly. Additionally, parents should also be informed about at-home teaching and be satisfied about the efficiency of this education to provide a foundation for students' motivation and academic performance. As a consequence, SNSs can open new doors and amplify education systems to activate students for knowledge construction and provide them a safe social communication and interaction environment supporting personal life goals in this global health crisis.

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CHAPTER 2

PROJECT-BASED VIRTUAL LEARNING IN SCIENCE EDUCATION*

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1. Introduction

Nowadays, the teaching methods used to reach information aims at learning by doing and experiencing, and especially learning to learn. Project-based learning, which is one of the learning methods used to achieve these goals, has opened the way for students to gain target behaviours related to cognitive, affective and psychomotor domains as a group or individually. However, recently, digital technology supported virtual learning environments have been widely used in science as well as in different disciplines, with the project-based learning method. Project-based learning supported by a virtual environment provided more research and educational opportunities for the student by removing time and space limitations in face-to-face and online learning. Therefore, in this chapter, the types of projects that can be prepared in both virtual and real environments, the selection of projects, the use of digital content in projects, virtual learning applications and the criteria to be considered for individuals in the 21st century in science education are discussed. Also, the role of project-based virtual learning in science education, which enables students to conduct research independently in projects such as projects, to produce and develop projects, to see their abilities, interests and differences, and to develop their competencies such as creativity, creative problem solving and high-level thinking, is examined and various suggestions are offered to the reader.

2. Project-based learning model

Project-based learning model is considered as a learning method based on progressive education approach where active learning is at the core and learning is determined based on personal traits. John Dewey's constructivism, Bruner's method of learning by discovery, Klipotrik's project method and Thelen's group research contributed to the development of this method (Kaptan & Korkmaz, 2003). Based on these approaches and

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* This chapter has been produced by benefiting from the theoretical framework of author's called "Investigation of the factors affecting the secondary school students' project based virtual learning competencies by structural equation modeling" master thesis.

methods, the core of the education program is entails the achievement of the goals determined by individuals at every stage of their development in real life through concrete projects and organization of free activities (Tuncer, 2009). The project-based learning was based on the fact that individuals are interested in real-world problems and develop a serious sense of curiosity and motivation as they acquire and apply novel knowledge when solving problems (Diffily, 2002). In general, the project-based learning method raises individual's curiosity and improves the creativity and imagination of the individual. Furthermore, project-based learning is an instruction method where the students acquire knowledge and skills by investigating and resolving an original, interesting and complex question, problem or challenge over a long period of time (Guitert Romeu & Romero, 2018). Also, the majority of studies on project-based learning method focused on the acquisition of basic skills such as intuitive thinking, analysis, observation and experimentation, data collection and interpretation, and discussion (Capraro, Capraro & Morgan, 2013; Deniş Çeliker, 2012; Nacaroğlu & Mutlu, 2016).

As a method, project-based learning could entail the concepts of "project", "" based "and" learning " separately as shown in Figure 1. (Kızkapan, 2015).

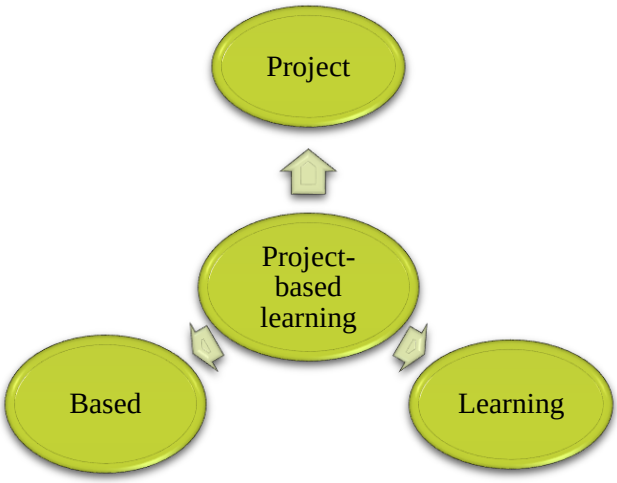

Figure 1. Project-Based Learning Concepts

The term "project" specifically indicates the processes of direction and projection of the learning activities and the associated learning to achieve the predetermined learning goal (Çevik, 2016). The term "based" emphasized the significance of the project as a process, not an objective. The concept of learning, on the other hand, emphasizes individual-oriented property of the process by focusing on the learner instead of the teacher

(Bayram & Seloni, 2014). Thus, project-based learning method is not a product but a process-oriented collaborative method that includes individuals' research skills and the ability to use adequate learning resources (Nuraydın, 2019). It is a curriculum development and instruction system that both improves problem solving strategies through the acquisition of lifelong learning skills and allows active learning by resolving the problems in the field of study (Liang, 2012). The system allows the individuals to take full responsibility in learning groups and to develop a habit of working in a team in cooperation with the team members. It also helps the transfer and exchange of knowledge and ideas. Gradually, it becomes a learner-based approach that allows the students to develop problem-solving, self-learning, and collaboration skills (Milentijevic, Ciric & Vojinovic, 2008; W.T. Ngai, 2007). It is also a learning method based on the development of projects, where the individuals could have the opportunity to implement and analyze the real-life projects as an extracurricular activity (Domínguez & Jaime, 2010; Helle, Tynjälä, & Olkinuora, 2006; Thomas & MacGregor, 2005).

Project-based learning aims to train individuals with scientific process skills, life skills and engineering/design skills required in the 21st century (Bell, 2010). Life skills include the skills of analytical thinking, decision-making, creative thinking, entrepreneurship, communication in native language and foreign languages, teamwork, initiative and entrepreneurship, problem solving, learning to learn, and in particular, research, collection, process, and critical and systematical employment of digital data. Engineering and design skills include innovative thinking skills (Daymaz, 2019; Korur, 2017). Teachers play a key role in the acquisition of these skills. Thus, teachers should guide the selection of new projects reflected in the individual's life and the student to complete these projects successfully (Bayraktar, 2015). The teacher plays a facilitating role in the acquisition of these skills and works with individuals based on valuable questions. Also, the teacher ensures that individuals acquire meaningful learning by determining a project subject, giving instructions, participating in learning by doing and experience activities (Balemen, 2016). The teacher ensures both the development of knowledge and coaches' social skills and carefully evaluates the learning of individuals based on their experiences (Efstratia, 2014; Han, Gopalakrishnan, Ji & Lee, 2015).

The implementation of project-based learning in an educational environment generally leads to various advantages and disadvantages. Mainly, it encourages individuals to conduct scientific work. It contributes to the acquisition of scientific process skills by solving questions and problems (Çelik, 2009). It was reported that it offers the opportunity to develop projects for individuals with various cognitive (mental), affective

and psychomotor levels (Milentijevic et al., 2008). It was suggested that scientific research methods and techniques allow individuals to acquire self-expression and presentation skills (Ayan, 2012). It was generally considered among the advantages of project-based learning that it provides individuals provide a new environment and opportunities do develop their projects with teamwork (Ardaiz-Villanueva, Nicuesa-Chacón, Brene-Artazcoz, Sanz de Acedo Lizarraga & Sanz de Acedo Baquedano, 2011; Balemen, 2016). Its disadvantages include the responsibilities of the teacher as a counselor, the increase in teachers' workload and the time allocated for learning, and disorderliness and derailing in the project when it lacks a well-developed project plan (Nuraydın, 2019). Thus, the project may take longer and could not be delivered on time. Furthermore, the school may not possess the necessary facilities and infrastructure for project development. It was suggested that individuals may not pay necessary attention to the project when they spend too much time on it (Keser, 2008).

In general, project-based learning is a comprehensive didactic approach where students learn with problem-solving activities, collaborative work, and have the opportunity to employ a variety of interdisciplinary skills (Guardia, Maina, & Baztan, 2018; Kakouri, 2018). Bell (2010) stated that project-based learning is not a supplementary activity that supports learning, but the basis of the curriculum, and most projects include reading, writing and mathematics activities due to their interdisciplinary nature. In interdisciplinary project-based learning environments, students are encouraged to combine topics and characteristics of various disciplines in a particular project (Biasutti & EL-Deghaidy, 2015). The projects are usually assigned based on student skills during the product development process, and learning is achieved in the project design through the transfer of knowledge between the members of a collaborative team (Hong, Yu & Chen, 2011). In this process, students work in collaboration to research and develop projects that reflect their knowledge, as well as self-learning via inquiry. Due to these properties, project-based learning includes learning experiences that integrate student knowledge and skills into real-life projects (Kakouri, 2018). The development of the project starts with a real-life problem and at the end of the process, a product is developed with scientific process skills. It was accepted that project-based learning that develops individual knowledge and improves creativity skills and imagination. Thus, in a learning process based on the project-based learning method, the cooperation of individuals, teachers, parents and the environment could lead to individuals with lifelong learning skill and know how to learn.

2.1. Project types and selection

A project entails the activities that were planned to conduct a study, the environment, duration, budget, human resources, stakeholders, and aims of which were clearly defined (Barron et al., 1998). According to the Turkish Language Institution, a project is a scientific work proposal that has been approved by the administration of institutions and organizations, the cost of which was calculated, accepted to be conducted on behalf of the private institution or the state within the short or long term, and planned and programmed in different fields in advance. In education, project could be defined as independent work conducted by individuals as a group or individually, about the acquisition of a concept, idea or skill to solve a problem (Kılıç, 2009).

Projects are the works that result in the development of a product. In other words, it is a set of activities that help provide in-depth knowledge on any subject by improving research-analysis skills. Also, they were considered as the practices that allow individuals to mature advanced skills and include a different dimension to the relationship between teachers and individuals (Viana, Jumadi, Wilujeng & Kuswanto, 2019).

Coşkun (2004) analyzed the project types in four categories: Topical Projects, Open-Ended Projects, Rigid Projects and Structured Projects.

1. Topical projects are school projects that were previously assigned as an annual homework where individuals conduct in-depth research on any topic they choose. These projects could be conducted individually or in small groups.

2. Open-ended projects improve the discovery and risk-taking skills of the individual, emphasizing creativity and have an undetermined outline. The most important criterion in such projects is the desire to conduct the project within a certain period of time.

3. Rigid projects aim to reveal the creativity of the individual with well-planned projects with predetermined limits. A school newspaper could be published within certain limits.

4. Structured projects, on the other hand, are determined by the teacher and the individual has to comply with this structure. Work is conducted within the predetermined criteria. Thus, the individual learns about the functions of the product that will be design from his teacher. For example, the individual is expected to develop a system to prevent the watermelon dropped from a certain height from splintering.

The science course could be defined as a discipline that aims to train individuals with query and questioning, critical and creative thinking, problem-solving, and analysis skills and lifelong learning habits (The

Ministry of National Education (MONE), 2018). Due to this discipline, individuals could cope with the rapid changes in their environment. In the science course, the individual could apply the acquisitions in daily life and achieve the experience of coping with daily problems with the employment of the project-based learning method (Bayram & Seloni, 2014). Individuals could select projects based on their personal interests and conduct projects to learn with the project-based learning method. Thus, there are certain criteria that should be considered when determining the types of projects that could be assigned in the science course (Türkmen, 2019).

Kaptan (2002) determined the types of projects that could be employed in the science course as follows:

1. Structure or Machine Projects: Individuals design structures such as a cell model, DNA model, or musical instrument and pay attention to what they learned when designing these structures. They indicate how the their designs work and how they could be improved.

2. Experimental / Research / Measurement Projects: An experiment is developed to investigate the effects of variables on an object. Individuals write a project report as a group and develop a model using the scientific processes.

3. Research and Discovery Projects: Individuals select a scientist or topic. They develop a presentation board to explain their findings based on primary and secondary resources. Individuals could select and use a wide range of tools on the internet. The most difficult part of scientific research and projects is the determination of the topic. Scientists follow two steps in the selection of a topic in scientific research. The first step is to identify the encountered challenge, the second step is to define whether the challenge is a problem.

Another important aspect of the project-based learning is the project topic (Hürşen, 2018). The most important stage in the determination of the project topic is the selection of the project topic by the individual. Because an individual who decides on the project topic is motivated, spends more effort and is happy during work (Wolk, 1994). Especially the selection of the project topic should be left to the individual. The teacher could also determine a topic. However, if the project topic is determined by the teacher, it should be based on personal interests and needs, development and learning levels of the individual. It was also suggested that a movie, book or article could be used when selecting the project topic based on the course objectives (Balemen, 2016). Furthermore, it should be kept in mind that a project is goal-oriented, the individual should noy spent unnecessary efforts, it should allow the individual to experience a sense of achievement, develop creativity skills and learn to take responsibility, and it should encourage individuals to research,

investigate, think, and solve daily life problems during the activities (Kaptan, 2002).

2.2. The significance and contributions of project-based learning in science education

Compared to social sciences, humanities and language instruction, the acquisition of the twenty-first century skills in science education requires a different approach (Chu, Reynolds, Tavares, Notari & Lee, 2017). Because science is associated with daily life situations, and since it includes complex events, the instruction should adopt an interdisciplinary approach to achieve a deep understanding. Scientific disciplines are not independent; an independent approach to these disciplines leads to artificial science instruction, distancing the instruction to the true nature of science (You, 2017). Thus, the employment of an interdisciplinary approach that includes real-life situations and allow students to cooperate could be suggested in science instruction. Project-based learning model is also a student-oriented method that possess the above-mentioned properties (Guitert et al., 2018)

In the age of information and technology, individuals are always at the center of the learning environment. In the new science curriculum, it was stated that the information should not be directly given by the teacher but should be structured in the mind (MONE, 2018). In scientific research, individuals should comprehend how to construct scientific knowledge, the properties of scientific knowledge, and science and its limits (Çelik, 2009). Thus, it is important for individuals to acquire knowledge and experience about the elements of the nature of science by conducting various scientific activities in projects. It was reported that project-based learning in science supports constructivism for the acquisition of skills such as discovering different ways of access to scientific knowledge in projects, approaching the problems encountered in daily life from various perspectives, and producing solutions (Atila, Diyaddin, Yıldırım & Sözbilir, 2015). Thus, it was emphasized that the science course should be instructed with a project-based learning approach that supports constructivist education (Güntaş, 2019).

We live in an era where technological advances are employed in many areas of life and the scientific knowledge of individuals improve continuously. In this era, individuals are required use their mental (cognitive), social and behavioral skills. In science education, it is more important to prioritize methods that aloow individuals to learn based on their learning levels and acquire various skills (Börekci, 2018). In project-based learning, individuals are perceived as the architects of knowledge and invention. The knowledge and invention are functional when shared with other individuals. For individuals who live as required by the era and

under normal conditions, the competencies to access and analyze information are expected in daily life. In science education, it was reported that effective use of project-based learning plays a key role in the acquisition of these competencies and making the learning process fun (Özel, 2013).

Project-based learning is an innovative learning approach that includes several strategies that are necessary to achieve success in the 21st century (Milentijevic et al., 2008). In this approach, in science course learning activities, individuals work in groups, collaborating with other members to research and develop projects. They reflect their knowledge to the social environment by developing an approach for culturally diverse individuals and conducting their own learning through questioning. It was emphasized that this approach would have critical benefits for the individuals and their training as individuals with changing, novel, vital technological skills, active communication skills and advanced problem-solving skills in science education (Bell, 2010).

Project-based learning, a modern learning method, allows the individual to access information by focusing on the individual in education, to solve daily life problems, and to use knowledge effectively by associating the knowledge between the disciplines (Başer, Özden, & Karaarslan, 2017). Individuals identify a problem associated with a course or a topic based on their interests and present various ideas by thinking creatively while searching for solutions to the problem. They plan, implement, and present these creative ideas by observing the optimal outcomes for the research problem. Thus, they learn by developing projects on how they would use the related information in their daily lives (Taşkın, 2018). In the science course, the project-based learning method aims to improve decision-making and problem-solving skills of individuals in daily life. Thus, it is important for science education to ensure the application and effectiveness of the project-based learning method.

In current curricula, the science course aims to train individuals with creative, critical thinking, problem-solving and decision-making skills, who acquired the habit of lifelong learning, researches, questions and analyzes (MONE, 2018). One of the aims of the science course is to train individuals who could adapt to the rapid changes in the world and the environment (Dağlı, 2014). Also, the development of creative and critical thinking skills is among the objectives of science education. Thus, the project-based learning method in science course could allow the individuals to adapt the acquired achievements in daily life with and to learn to cope with the daily life problems (Bayram & Seloni, 2014). Because, individuals who achieve the objectives of the science course with this method could acquire advanced cognitive skills and permanent knowledge through the adaptation of the learned knowledge in daily life

(Kaptan, 2002). Furthermore, in science courses, individuals learn the employment of various methods to solve daily life problems and acquire novel knowledge about life. Also, methods such as brainstorming, discussion, invention, experimentation, laboratory practice, etc. are used in the science course (Kaptan & Korkmaz, 2003). However, in most methods, the course entails teacher-centered instruction (Barron et al., 1998; Milentijevic et al., 2008). In project-based learning approach, the individual conducted projects with different methods to learn the topic. Furthermore, individuals have the opportunity to make sense of the information by improving their scientific knowledge and skills in project-based learning. Also, they develop critical thinking skills through self-interpretation and in-depth analysis of the learned knowledge.

Project-based learning is consisten with the constructivist approach and allows individuals to demonstrate advanced thinking skills (English & Kitsantas, 2013). It supports various skills such as permanent knowledge, life skills, research, group work, high task motivation, communication skills and taking initiative, which are significant in science education (Börekci, 2018; Efstratia, 2014; Özel, 2013). Also, previous studies demonstrated that project-based learning, where individuals are active in the learning process, also contributes to meaningful learning (Tonbuloğlu, Aslan, Altun, & Aydın, 2013). Thus, based on the above-mentioned contributions to science education, it could be suggested that the employment of project-based learning plays a key role in science course instruction.

3. The significance of virtual learning applications in science education

Natural sciences entail human acts to research, systematically observe, investigate and explore the nature and the environment due to human sense of curiosity (Raziye, 2019). Since technology is the reflection of science on applications, it could be suggested that science is intertwined with technology. The aim of science is to understand and explain the natural environment, while the aim of technology is to fulfill the demands and needs of human beings by changing the natural world (Koç & Böyük, 2013). The main objective is to train science and technology literate individuals in science education. Thus, science education aims to train individuals who could produce solutions to daily life problems and develop a positive attitude towards science and technology through the association of technology and science (Hançer, 2009). Therefore, the inclusion of technology-assisted virtual learning applications in science education would facilitate the employment of scientific concepts, principles and theories to explain the nature and the relationships between natural phenomena. The presentation of these knowledge with visual figures, animations, or simulations, and concrete multimedia content in the virtual

media and course software would lead to a rich visual instruction. Previous studies reported that it was important to employ virtual learning applications in science education (Kayabaşı, 2016; Yıldız, 2019).

Science is considered significant since it provides solutions for daily life problems and leads to the development of innovative technologies that facilitate life (Kızkapan, 2015). Effective science education is a must to achieve these goals. Effective science education could not be independent of technologies. The technologies that could be utilized include computers, mobile devices and especially virtual reality applications, and virtual reality technologies are of interest in military, medicine and game industries (Aktamış & Arıcı, 2013). The employment of virtual technologies in education allows active learning and more interesting and intriguing classes. Furthermore, most educational studies on the employment of augmented reality and virtual reality applications mostly focused on science (Timur & Özdemir, 2018). These studies aimed to investigate the effectiveness of augmented reality applications on the instruction of abstract concepts, which are prevalent in scientific fields and difficult to understand. The augmented reality is a virtual learning environment created by the transfer of real events to the computer environment with various software that allows the active use of all senses by the individuals. It was suggested that science education would be effective when virtual applications are adopted in learning environments.

Erümit (2013) developed a web-based virtual material for college biology instruction. In the study, design criteria were developed for virtual course materials in web-based distance science education. It was reported that certain criteria should be considered when developing virtual learning applications. These could be discussed in four sections as seen in Table 1.

Table 1. It was reported that certain criteria should be considered when developing virtual learning applications.

Instructional Conformity

- Particularly including the evaluation section
- Creating a systematic structure of the subjects
- To be printable without making the content difficult
- Selection of applications with different learning styles such as auditory and visual

Curricular Conformity

- Preparation of content by experts in their field
- Keeping teacher-student-designer communication continuously while creating the content

Visual Conformity / Visual Competence

- Using realistic and vibrant colors
- Using fun visual elements, animation and simulation
- Harmony of color usage between screens
- Highlighting the important places with bright colors
- Consistent transition between screens when using color

Coding Conformity/ Technical Competence

- Switching between screens depends on user request
- Having an easily accessible help menu
- Features of the technological tools and systems in which the materials will be used
- The material is accessible to the student.

1. Instructional Conformity: Virtual learning materials should reflect the systematic structure of the topics based on the instructional adequacy criteria, the content should allow printouts but should not be difficult, the applications should fit various learning styles such as audiovisual, and especially these should include evaluation facilities. It was determined that the employment of virtual learning material was considered important by individuals and the course instructed with the material raised personal interest and improved the motivation. The science course is perceived as difficult since it includes several scientific concepts, reducing the science course achievements. Thus, science education should be restructured and instructed based on the new developments. Therefore, it is necessary to design qualified learning material to include virtual learning applications in science education.

2. Curricular Conformity: It was emphasized that the content should be developed by field experts based on the curricular conformity criteria, the field experts should be trained in design, and the communication between teacher-individual-designer should be maintained during development.

3. Visual Conformity / Visual Competence: For visual competence, realistic and vibrant colors, entertaining visual elements, animations and simulation should be used in virtual learning materials, important places should be highlighted with bright colors, and the color variations should be harmonious between the screens. It was reported that virtual learning materials should conform with visual requirements, effective visual multimedia features should be employed to raise the interest and focus on important concepts. Furthermore, it is important to use colors to influence the individual, and virtual competency of the learning material should attract the attention and interest of the individual and increase motivation.

4. Coding Conformity / Technical Competence: The transition between the screens should be controlled by the user, an easily accessible help menu should be available, the properties of the technological tools and material systems should be open and accessible by the individual. The technical competence of virtual learning materials is another important criterion. The technical competence of the materials entails the construction of the simulations based on the course topics. This would improve the interaction of the individual with the material.

The design of virtual instruction material based on the above-mentioned criteria would lead to a qualified design. Also, individuals would appreciate the employment of multimedia applications such as dubbing, animation and simulation, since it would suit all learning and instructional styles (Erümit, 2013). Thus, interesting virtual learning material in science education would lead to effective instruction desired by the individuals. It was determined that virtual learning material developed based on the learning styles positively affected creativity, academic achievement and motivation (Bajraktarevici, 2003; Dedeoğlu et al., 2013).

In conclusion, since the development of virtual learning material for science education requires a long and difficult process, the design criteria are required to facilitate the process and improve the efficiency In the design of virtual learning materials for the science course, instructional conformity, curricular conformity, visual conformity, and coding conformity of the material should be taken into account.

Virtual worlds and augmented reality are popular research topics. Several studies demonstrated that desktop and laptop computers, tablets and mobile phones improve the desire to learn. In "The analysis of the impact of 4d mobile applications on science education achievements and student attitudes" by Kayabaşı (2016), it was reported that the Space 4D

mobile application raised interest and improved the attitudes towards the course, leading to active participation (Kayabaşı, 2016). In another study, it was determined that virtual instruction software contributed to cognitive and affective learning (İbili & Şahin, 2013). Similar educational applications developed with technological tools would stimulate the imagination of individuals by presenting various multimedia elements and increase the motivation for learning and the effectiveness of instruction. Also, these applications are considered important to improve excitement about learning (Cheng et al., 2016).

4. Project-based virtual learning and its significance in science education

Virtual learning applications emerged around the world, especially at educational institutions. According to the United States National Statistics Center (NCES) reports, the share of digital learning in educational institutions reached 72% and more than 1.6 million individuals enrolled in virtual learning courses between 1994 and 1998 (Phipps & Merisotis, 2000). This transformation was due to social, cultural and economic factors, and these elements develop and spread rapidly, and new discoveries emerge. This makes it difficult for educational institutions and teachers to follow these rapid developments. Although these developments end certain research, it was predicted that the number of new schools and employment of new personnel will decrease despite the increasing demand in education (Taşpınar & Tuncer, 2007). Thus, it was suggested that education and training could be provided to a large number of individuals simultaneously in digital learning courses. These developments were considered remarkable and worth conducting research. The virtual learning applications focused on project-based learning since it is based on individual and group education. Because it is clear that project-based learning supports digital learning by providing query, research and investigation, individual and group work skills, and allowing easy and effective project tasks (Ersoy, 2006). Thus, it was emphasized that project-based learning, an approache that allows individual and group digital learning, could be employed in virtual education (Dedeoğlu et al., 2013; Tuncer, 2007; Yılmaz, 2012).

Today, it is clear that individuals require different knowledge and skills in education and instruction (Börekci, 2018). It is important to improve education to adapt to the information age and future communication technologies (Aslıyüksek, 2016). In digital project-based learning in virtual media, the required skills are 21st century skills and global competencies (Ahonen & Kankaanranta, 2015). It was observed that the acquisition and development of 21st century skills and global competencies are the most important vision for educational institutions (Flumerfelt & Green, 2013). Digital learning, which supports the project-

based learning for active employment of instructional technologies to achieve the above-mentioned vision, includes project-based virtual learning.

The objective of educational applications in the age of information and technology is to improve the personalized education environment based on the principles of lifelong learning, distance education and autonomous learning rather than mass education (Atik & Ata, 2018). Furthermore, current education methods aim to activate creative and critical skills, daily life problem-solving skills, and to train self-confident, constructive, consistent, and social individuals (Ahonen & Kankaanranta, 2015). The particular emphasis is always and overwhelmingly on individuals/learners. Based on these goals, societies have adopted virtual learning in virtual learning environments based on their resources. Thus, tools and content should be developed, diversified and continuously updated based on these philosophical principles (Uzun, 2017).

Teachers and instructional designers tend to create environments based on social and collaborative learning to allow interaction between learning individuals. Virtual learning communities became popular with the employment of information technologies in education. The classroom and outdoor learning environments where the processes and activities could be conducted are considered as virtual learning environments. Thus, it was reported that since digital learning environments have a functional impact on the participation and sustainability in in-classroom or out-of-the-classroom learning processes to conduct individual and cooperative learning activities, they also contribute to project-based virtual learning (Yılmaz, 2017).

The employment of project-based virtual learning is possible thanks to digital technologies in educational environments (Kakouri, 2018). Effective and active employment of digital technologies is important in education, as well as in social life. It is also adequate for group projects in a virtual environment, as it allows multiple users to easily create and organize collaborative digital technologies such as social networks (Ng M. W., 2016). Digital technologies, which significantly changed the way individuals share information and interact with each other in groups, also support project-based learning in virtual environments. Thus, it is important for individuals to employ digital technologies and to acquire project-based learning competencies in virtual environments (Yılmaz, 2012). Furthermore, it is known that individual attitudes are also important in the effective use of digital technologies by individuals in educational settings (Erten, 2019). In studies on information systems, attitude was considered to have an important impact on successful use of information systems in any institution (Cabı, 2016). The individual attitudes towards digital technologies should be determined before instructional

environments are designed or organized to introduce these tools in educational environments (Gokhale, Brauchle, & Machina, 2013).

Science course is instructed in every level of education. Science course is where most individuals experience learning problems (Hançer, Şensoy, & Yıldırım, 2003). It was observed that individuals learn more slowly than expected, experience difficulties in learning basic concepts, and could not comprehend these concepts comprehensively in the science course (Kızkapan, 2015). Especially theoretical instruction of this course not only negatively affects individual achievements, but also leads to misconceptions. Especially in primary education, the problems in establishing the relations between the piece and the whole and cognitive misconceptions could lead to serious problems in future education levels. It is not always possible to conduct applications in science classes, the experiments and activities required to learn various concepts are dangerous or problems are experienced in the procurement of necessary materials. Also, certain abstract concepts could not be instructed with experiments. Thus, studies reported that the employment of project-based virtual learning applications in science education was effective on the elimination of these problems (Akerson, Carter, Pongsanon, & Nargund-Joshi, 2019; Ardaiz-Villanueva et al., 2011; Ersoy, 2006; Orhan & Men, 2018).

Basically, science focuses on process, product and attitude. It focuses on how to obtain scientific knowledge as a process. As a product, it emphasizes the scientific knowledge outcomes. As an attitude, it pays more attention to scientific efforts to train and instill positive values in individuals. Thus, individuals who study science should be assisted to develop their potential and creativity, and it is also important in science education to equip them with a learning model adequate for the acquisition of required skills. Gunawan et al. (2017) investigated the effects of the virtual media model on the creativity of individuals. In the study, they observed that the virtual media supported project-based learning model significantly improved the creativity skills of individuals (Gunawan, Sahidu, Harjono, & Suranti, 2017).

Today, employers need individuals who could solve problems, communicate effectively, have teamwork and leadership skills, and could develop a learning strategy in the workplace (Bell, 2010). Competencies acquired with the approaches such as project-based virtual learning are significant in the acquisition of these skills. These competencies include project work, project execution, project introduction, project self-control and project finalization competencies (Yılmaz, 2012). These competencies allow the individuals to acquire t21st century and global skills. Digital technologies also have a great impact on the acquisition of these competencies (Keskin & Yazar, 2015). Also, recently, digital technologies were introduced as a learning tool in all education levels. Individuals of the

digital generation, known as the generation Z, have productive social media skills, could use technology to solve problems, and live a technology-oriented lifestyle (Kapil & Roy, 2014). For these individuals to acquire digital literacy, adopt to the changing conditions in the digital age, it is important to determine their attitudes towards digital technologies and to support their development and adaptation during educational activities (Somyürek, 2014). It was also considered beneficial to include and use digital technologies in courses (Sezgin, Erdoğan, & Erdoğan, 2017). Thus, individual attitudes towards digital technologies are primary determinants. In other words, raising awareness about the employment of technologies, recognition of their positive and negative effects, and determination of the significance of digital technologies in the lives of the individuals are important (Cabı, 2016). Based on these inferences, it was deemed important to determine individual attitudes towards digital technologies to conduct best educational and instructional applications and train individuals who could use digital technologies effectively.

5. Conclusion

It was emphasized that rapid technological advances led to significant changes in the development of the learning processes due to their impact on educational environments (Lerche Nielsen & Birch Andreasen, 2013), and the current learning styles have been changing due to the introduction of digital learning environments. Thus, digital technologies have been employed as a learning tool in distance education at all levels (Atik & Ata, 2018; Özen, 2019). The holistic approach that integrates the human-labor processes and technological elements based on changing social requirements and the facilities provided by information and communication technologies is the digital technologies. At the peak of these technologies, which introduced radical changes in business processes and social life, human mind prevails with several technologies such as cloud computing systems, internet of things and artificial intelligence (Timur & Özdemir, 2018). It was considered important that educators could employ digital technologies to find solutions to current problems, they will make life easier, lead to productive use of time, energy and finances, and contribute to the related field. In conclusion, acquisition of project-based virtual learning competencies, and determination of the correlation between the attitudes of individuals towards digital technologies based on the sub-dimensions are important in science education.

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CHAPTER 3

AUTHENTIC LEARNING IN SCIENCE EDUCATION

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1. Introduction

In this chapter, "Authentic Learning Approach" and "Authentic Learning in Science Education" are discussed. Thus, topic such as authentic learning and its attributes, the description of authentic learning in science education, basic elements in authentic learning, and authentic tasks are addressed. Furthermore, a course syllabus draft based on the authentic learning approach in science education is presented.

In the twenty-first century, every social segment in the world and in Turkey is affected by rapid advances in science and technology, and faced with complex problems and difficulties associated with the social structure, social, political, economic and cultural changes (Aynas, 2018). Thus, countries strive to modify and improve their education systems due to the global scientific and technological advances to prepare future generations to face these challenges, to encourage their in-depth reflection, allow them to develop broad, transferable skills and knowledge and active learning skills (Yahaya, Rasul & Yasin, 2017). In these processes, the requirement for a complete and comprehensive education system, which aims the acquisition of high-level skills, including critical thinking and problem solving, communication, collaboration, and twenty-first century skills such as creativity and innovation (Bhagat & Huang, 2018; battelleforkids.org). Thus, the developments in education systems and the changes implemented to improve education systems led to the development of new theories, views and research on education and instruction, different methods, new instructional approaches, practices, learning environments and evaluation methods that replaced the conventional approaches (Özden, 2002).

In the Turkish education system, changes were introduced due to the fact that the curricula were rote-based, disconnected from daily life, teacher-oriented, theoretical and incompatible with the practice, and as a result of scientific and technological advances (Semerci & Yelken, 2010). In traditional instruction methods where teachers were at the center before these changes, teachers were considered as individuals who attempt to instruct the curriculum without considering the student requirements and perceive education as a means to shape behavior (Titiz, 2000). According

to Nicaise, Gibney, and Crane (2000), since the student is passive and the learning and instructional activities are limited to the classroom in the teacher-oriented education system, the approach fails to improve student knowledge. Thus, the courses have a negative impact on students who lack learning initiatives in the teacher-oriented education system (Herrington, Reeves & Oliver, 2006; Rule, 2006). This has changed in the current educational practices that provide students with the learning environment they deserve, include the students in active learning, since these developments and changes altered the student profile (Titiz, 2000).

The current changing and revised education systems primarily aim the acquisition of basic knowledge and skills, the development of daily life problem-solving skills, the acquisition of various skills such as production, critical thinking, creative thinking, communication, research and inquiry skills, and to train individuals who are aware of their responsibilities and promote the knowledge required to become lifelong learners (Bay et al, 2010; Spector, 2015; Spector, 2018). These skills are also among the objectives of the revised science curricula. The science curricula aim the development of students' problem-solving, decision-making, critical thinking and research-inquiry, learning by doing, and high-level experimentation and observation skills (Kaptan, 1999; Kırıkkaya, 2009 Ministry of National Education (MoNE), 2005; MoNE, 2013; Sellüm, 2020). In efforts that aim a student-centered reorganization of learning, the important goal is not the acquisition of knowledge, but the employment of knowledge and generation of new knowledge with these skills. Thus, the alternative theories, strategies and methods to conventional methods aim to maximize the benefits of education and the success of instruction (Butakın & Özgen, 2007). One of the prominent new instructional approaches is authentic learning, in which student experiences at school and in daily life are associated, and the method emphasizes that learning should be based on real life (Barab Squire & Dueber, 2000). Authentic learning is a pedagogical approach that encourages students to solve real-world problems, as the approach improves student motivation, provides better learning opportunities, prepares the student for a better future, facilitates the comprehension of complex concepts, and blends theories and learning (Har, 2013). Instruction and learning environments organized based on the authentic learning approach are required to train students with better, more concrete comprehension and knowledge and to improve the quality in classroom learning (Barab et al, 2000). In the science course, students could access the current knowledge, could produce solutions by doing and living in authentic learning environments.

2. Authentic Learning

"The only source of knowledge is the experience."

Albert Einstein

Authentic learning is an approach that aims to improve the motivation and learning experiences of pre-service teachers through learning and instructional activities that reflect real life conditions (Bennet, Agostinho & Lockyer, 2005; Borthwick, Bennett Lefoe & Huber., 2007; Wagner, 2008). Bektaş and Horzum (2010) described authentic learning as learning that is same or similar to the reality an educational approach that includes the exploration of the relationships in real-world problems and projects associated with daily life, discussion and construction of meaningful concepts (Donovan, Bransford & Pellegrino, 1999). Furthermore, authentic learning also considers student perspectives to improve the meaning of the learning content through the development of tasks similar to real life problems (Andersson & Andersson, 2005).

Authentic learning, which is not as straightforward and easy to comprehend as standard school learning, employs high-level learning in problem solving by assigning an adequate context to a word or phrase. Authentic learning is not limited with classroom learning. However, it allows the students to introduce their experiences, knowledge, beliefs and interests in the classroom. Thus, students try and employ structured knowledge rather than rote-based information (Mehlinger, 1995). This learning environment allows students to combine the concepts and theoretical knowledge learned at school and apply them to real-life conditions (Bennett, et al., 2005; Borthwick, et al., 2007). Students are not only instructed but can also directly associate their theoretical knowledge with real-life tasks, leading to a unique experience, albeit indirectly (Granton & Garusetta, 2004). In authentic learning, the more exposed students are to real-life environments, the more likely they would believe that their knowledge and skills would improve and every problem could be solved with various methods (Lombardi 2007).

Certain attributes were determined to demonstrate the applicability of authentic learning in classrooms, an instructive approach that allows students to discuss, explore and collaborate in real-world settings using tasks that aim to to create new knowledge and new real products in learning activities (Brown Collins & Duguid, 1989; Knobloch, 2003; Mims, 2003; Reeves et al., 2002; Rule, 2006). These attributes are presented in Figure 1.

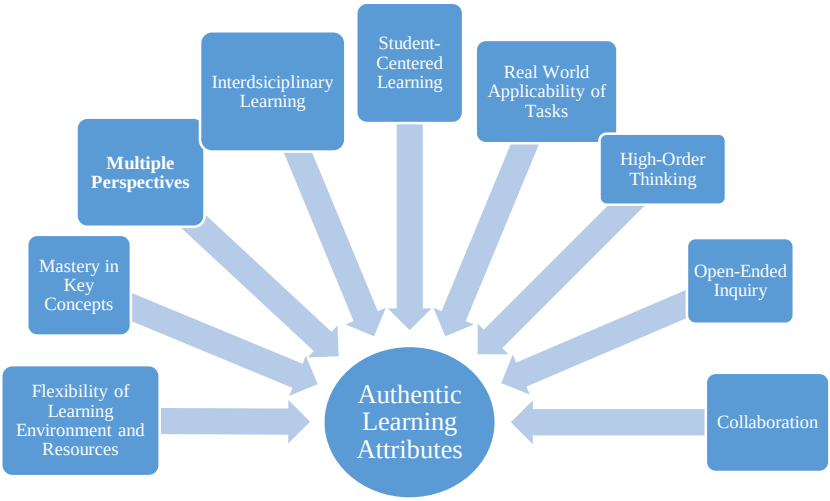

Figure 1. Authentic Learning Attributes

Finally, in courses designed with the authentic learning approach, students could resolve real-life tasks, develop interdisciplinary perspectives, produce various solutions to issues that could be researched with various methods, develop skills such as teamwork, collaboration and leadership, and improve self-awareness about learning levels and self-evaluation skills while reflecting on the outcomes. Thus, authentic learning allows the students to solve real-life problems and associate the process with the course topics. It could be suggested that when students encounter daily-life problems, the knowledge and skills they acquire in the classroom allow them to cope with these issues, and the approach helps them to find a solution by connecting to the real world. Authentic learning could only be achieved through activities and tasks that include real-world problems.

2. Authentic Learning in Science Education

Science education is essential for prior knowledge, abilities, interests and competencies of the students. More precisely, the inclusion of the students in the process of understanding science as part of their daily lives could provide a significant foundation for their achievements in real life (OECD, 2012). Thus, it is necessary to allow the students to develop

emotional, cognitive and social skills such as expressing their emotions and ideas, making prepositions, or rejecting an idea for their achievements. The curricula developed with this approach allow an education based on the idea that learning is not limited to school or classrooms but entails all life experiences and paves the way for further learning (MoNE, 2018; OECD, 2015). The science curriculum determined various field-specific skills that aim to develop science literacy, invest in their competencies to tackle scientific issues and ideas, encourage students to reflect, participate in active learning, associate prior knowledge, explore the novel knowledge based on their nature (MoNE, 2018). These skills are presented in Figure 2.

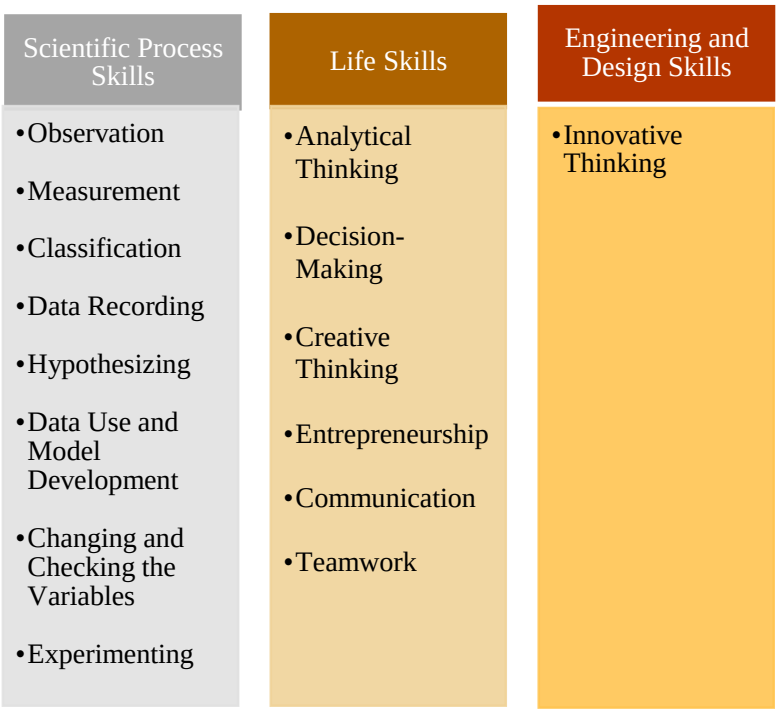

Figure 2: Field-Specific Skills in Science Curriculum

Due to scientific and technological advances, the science curricula have been revised and various strategies and approaches have been adopted in the implementation of the curricula to allow meaningful and permanent learning in a student-centered learning environment. Authentic learning was one of these approaches and considered as an instructional approach that leads and facilitates learning to intruduce real-world experiences in the classroom (Banas & York 2014; Lombardi 2007; Semerci & Yelken, 2010). In the instruction of the science course, it is important for the students to tackle real-world problems that include authentic tasks that

allow them to investigate the problems they encounter in their lives (Globe, 2021; Johnson et al., 2012;). In curricula that aim to allow the students to understand the development of scientific knowledge through direct participation in scientific processes and research to understand the real world, and the basic philosophical attributes and real-life problems should complement one another for authentic activities. Thus, Roth (2012) reported that students should experience the scientific research process with at least five approaches similar to the scientists:

i. Students learn about real life problems in their current environment,
ii. Students experience the nature of scientific work and knowledge with uncertainty and doubt,
iii. Learning (in compliance with the curriculum) is based on the current knowledge level of the students (wherever they are) and determine the activities that would be developed,
iv. Students consider themselves as part of research groups where knowledge, applications, resources and discourse are shared,
v. In these groups, students could also draw on the expertise of other more knowledgeable individuals, including peers, mentors or teachers.

Students who experience these five processes conduct research in groups and create permanent learning environments with activities designed with the authentic learning approach. Thus, they are allowed to participate in scientific research, and acquire various field skills. According to Pizzini, Shepardson & Abell, (1991) these skills could be listed as follows:

- They can identify problems and solutions and experience the opportunity to test these solutions,
- They can design their own operational steps and data analysis methods,
- They can formulate new questions based on prior problems and solutions,
- They can develop questions based on prior knowledge,
- They can associate their experiences with various activities, scientific concepts and scientists, and
- They can share and discuss the operational steps, research findings and solutions.

The teachers play a key role in the management of the scientific research processes the students participate in authentic learning environments and in the development of authentic activities associated with the science course topics. Thus, the Australian Science Teachers Association (ASTA, 2007) developed certain field-specific competencies

for science teachers. These competencies include 3 basic groups and include 11 items (ASTA, 2007):

Professional Knowledge

1. Command of science and science curriculum
2. Vocational proficiency to instruct, learn and evaluate,
3. To determine the factors that affect students and learning.

Professional practicality

1. To design adequate and consistent learning programs,
2. Development and maintenance of challenging but safe learning environments,
3. To encourage students to produce scientific knowledge via research,
4. To investigate the ways to improve the student attitudes towards basic scientific ideas,
5. To improve the conscious decision-making capacity of the students,
6. To employ various strategies to monitor and assess student learning.

Professional Attributes

1. To analyze, evaluate and improve the instructional practices to improve student learning,
2. To work in and outside the school equally to improve science education.

The science teachers also have responsibilities in designing, implementing, and guiding authentic learning environments, and in in-depth reflection, emphasizing other dimensions, and providing feedback (Bhagat & Huang, 2018; Edelson, 1997; Gordon, 1998;). While they encourage the students to solve the problems, they should also allow them to express themselves based on their knowledge and social skills.

4. Main Components of Authentic Learning

Although the authentic learning approach has been introduced in the 1980s, it was not fully implemented due to the gaps between theoretical education and practical instruction (Yahaya et al., 2017). Because there were differences between the learning experiences in educational institutions and real-life learning (Herrington, Reeves and Oliver, 2006; Rule, 2006; Stein, Isaacs & Andrews, 2004). To close the gap between classroom and real-life learning, the student should be prepared for the authentic learning environment. Thus, authentic learning would allow the students to associate the real-life practices and normal education to learn theories and concepts and allow them to recognize their identity via social

interactions with their peers and the society (Borthwick, Vd., 2007; McKenzie, 2002;). According to Revington (2018), authentic learning has 12 essential components that reduce the gap between the learning experiences at school and the real world, encourage the students to produce a concrete, beneficial product based on real life problems, and ensure authentic learning. These essential components are presented in Figure 3 (authenticlearning.weebly.com; Revington, 2012; Revington, 2018).

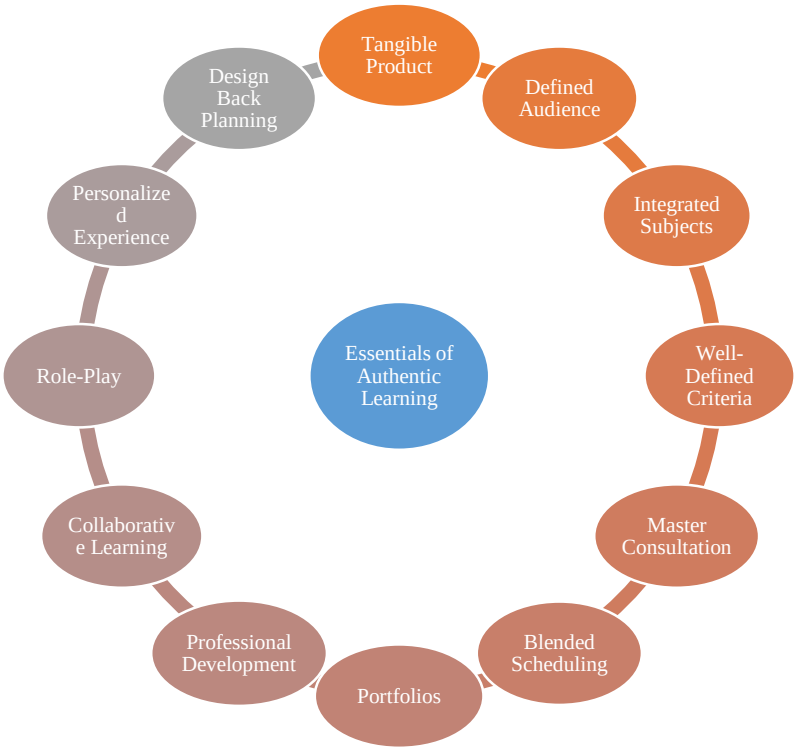

Figure 3: The Essentials of Authentic Learning

1-Tangible Product: The aim is to produce a tangible product that could be actively shared with the world.

2-Defined Audience: The determination of the target audience for the activities provides important, specific information for teachers and students to conduct an efficient and effective planning.

3- Design Back Planning: Once the objective and the target audience of the activity are clearly determined, an authentic learning design plan is developed. It is important to make a list of information that includes the associations with the curricula, resources, and the schedule.

4-Well-Defined Criteria): The criteria should be clearly defined and consistent with the goal.

5-Role-Play: Students have almost no chance of role-play in conventional education approach. The similarity of a learning based on real life experiences with the reality would strengthen the learning experience. It would be extremely useful for the students to enact roles (cook, accountant, doctor, architect, etc.) that reflect and extend learning environments.

6-Integrated Subjects: Similar to real life, learning in the classroom is not specific to a topic. Authentic learning activity planning could include various disciplines such as mathematics, social studies, science, painting, music, physical education etc. that are associated with the actual activity. The curricula are full of opportunities to integrate the topic and collaboration with other branch teachers.

7-Blended Scheduling: A traditional curriculum includes an equal learning and instruction period for each student and each content. This may limit the opportunities they for the students and teachers to learn within the allocated periods. Extended time periods could be designated to meet the expectations of the curricula for the development of creativity and to achieve a better focus.

8-Collaborative Learning: Authentic learning activities are excellent opportunities to allow students to develop collaboration skills and cooperate as a team. Collaboration is very important in both real life and in classroom.

9-Personalized Experience: An authentic learning activity provides open-ended opportunities for the students to discover personal interests and creativity. Even though the student is a part of a team, their experiences and perceptions may be quite different. Thus, even when all students work on a project, all students should be allowed to express their opinion since these might vary. Furthermore, after the basic work is completed, students with a personal interest in the project should be encouraged to improve their knowledge.

10-Portfolios: Portfolios are the collections that include student research, drafts, contact information, consultation notes, lists, diagrams, worksheets, grades etc.

11-Master Consultation: Although real-life activities developed by the teachers create a real learning task, it still requires interaction with a master. The students should know to request the required expertise in an effective and polite way, investigate and determine the experts in the society and to conduct this inquiry safely and efficiently.

12-Professional Development: Since the teacher is a counselor who guides the students instead of an authority figure, educators should be open to professional development opportunities Şimşek, 2000). The teachers are not expected to be experts in all fields. Thus, it is very important for all educators to acquire new skills and processes for professional development.

Other models were developed in addition to the basic components of authentic learning environment developed by Revington 2012. There are 9 basic task, activity and evaluation components that lead to authentic learning according to Herrington (2006). These are presented in Figure 4.

Figure 4: Authentic Learning Components

Stein, Isaacs and Andrew (2004) suggested a theoretical model that included design, development and implementation of a curriculum with authentic learning approach. The model included 3 elements associated with the curriculum and 3 elements associated with student attributes. The 3 elements associated with the curriculum were as follows:

1. Targeted scope of learning
2. Teaching and learning activities and resource strategies
3. Program evaluation.

The 3 elements associated with the students were as follows:

1. The trainees' authentic learning style
2. The learning style in certain fields
3. The natural features of certain fields

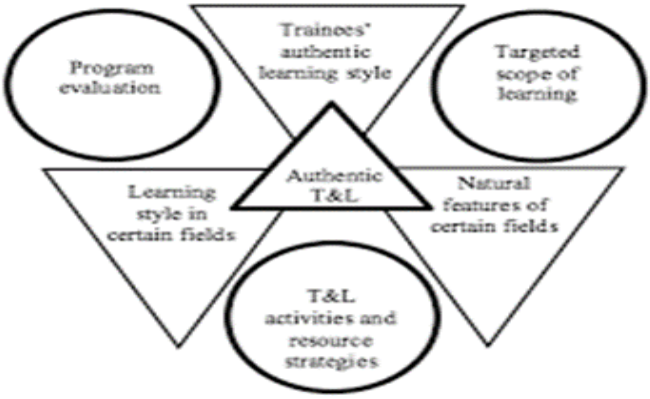

Figure 5: Stein, Isaacs and Andrew model (2004)

In conclusion, authentic learning that includes consistent, meaningful and purposive activities is an instructional approach that allows students to discuss, discover and collaborate to create new knowledge and tangible products in real-world (Brown, et al..1989).

5. Authentic Tasks

The authentic learning process starts with authentic tasks and conducted with authentic activities and assessments. Authentic tasks should provide knowledge and skills that the student could use to resolve current of future problems. Authentic events should allow the employment of problem solving, critical thinking, synthesis skills in real-world context (Knobloch, 2003). When authentic tasks are original, meaningful and associated with the real world, students would value their learning more. Because it is important for them to associate the knowledge they learn in school with their private lives, the knowledge should be consistent with their needs and interests. The value of authentic tasks surpasses the class and associates the student knowledge with the "external world". The tasks are meaningful as long as they allow the students to make sense of their experiences (Anderson & Pešikan, 2016; Mayer, 2001;).

A real task allows the students to acquire rich learning experiences that include critical thinking, decision-making skills, and apply their experiences at work, at home or in the society. Tasks provide opportunities for the students to relate with the real-world situations, connect with their interests and investigate the topic in depth (Education.vic.gov.au). The completion of projects and tasks allow the students to present concepts, skills, and higher cognitive knowledge when addressing real world issues. There are several properties of authentic tasks in the instruction (Terhart, 2003; Bennett, 2006; Rahman, 2014). These properties are presented in Figure 6.

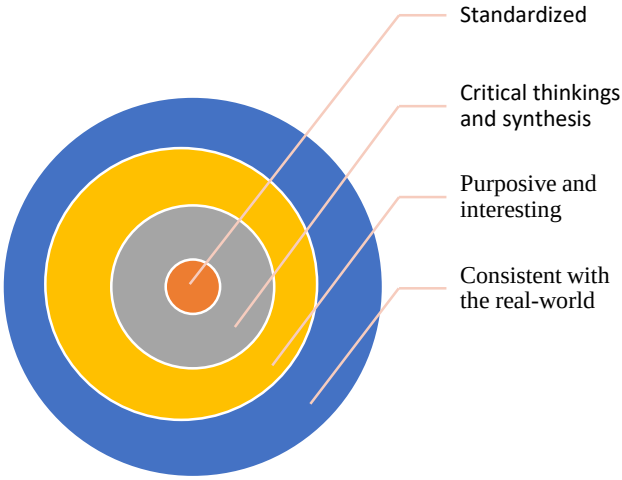

Figure 6: The Characteristics of Authentic Tasks

The authentic tasks that comply with the standards, objectives and interests improve critical thinking and synthesis skills in students when they are based on real world problems. The development of authentic tasks is also very important and the principles for development are presented below (Herrington, 2006; Borthwick et al., 2007):

1. Well-defined,
2. Allow students to divide into sub-tasks,
3. Support student experiences, work, and real-world associations,
4. Supported by previous studies,
5. Allow the development of a multiple perspective,
6. The content should allow the acquisition of high-level skills in the field,
7. Allow the students to associate prior and novel knowledge,

8. Allow collaborative and individual presentation of learned knowledge,
9. Allow interdisciplinary learning,
10. Allow the application and integration of knowledge and skills in various topics,
11. Allow an evaluation that reflects real-world analysis and integrated with the main task,
12. Allow the production of new knowledge,
13. Should be completed in a long period.

Thus, it was observed that authentic tasks that require the students to resolve real life problems in collaboration with their peers were important. Students with authentic tasks could benefit from and implement the acquired knowledge based on current conditions. They could also employ the acquired knowledge in a different field. Thus, they associated their academic and personal lives. It could be suggested that when the students who undertake authentic tasks are analyzed based on cognitive skills, their active thinking skills develop, and they have the opportunity to implement their ideas in the classroom and integrate them in different fields. It could also be suggested that authentic tasks could serve as a bridge between the knowledge acquired in the classroom and the employment of this knowledge in real world.

A Sample Science Course Activity Developed with the Authentic Learning Approach

Course: Science

Grade: 5

Unit: Human and Environment

Topic: Human and Environment Relations

Time: 40 min. *8

Achievements

On environmental pollution, environmental protection, human-environment interaction (human impact on environment), local and global environmental problems,

1. Students provide examples for advantages and disadvantages of human-environment interaction,
2. Students conduct a research on the solution of a local or national environmental problem and present the findings,
3. Students express the significance of the interaction between humans and the environment,
4. Students explain the advantages and disadvantages of human-environment interaction with examples,

5. Students explain the adverse effects of environmental pollution on human health,
6. Students implement their deductions about future environmental problems due to human activities.

1st Stage

The educator primarily instructs the students to examine the environment and points to the animate and inanimate objects around them. The educator allows the students to realize that they shared the environment with several animate and inanimate objects that they could not have estimated with a brainstorming activity. After the students become aware of various environmental issues and problems that affect the world, the educator creates student groups based on student interests and expectations in detailed knowledge. Groups begin to investigate the positive and negative effects of humans on the environment.

2nd Stage

Groups collect data on the environment problems that may occur due to human-environment interaction, the causes of environmental problems, the effect of environmental problems on living beings, the measures against environmental problems, and recommendations for the solution of environmental problems. The collected data is discussed during group presentations. The discussions end with a decision on whether the collected data were sufficient.

3rd Stage

A product that could contribute to the solution of environmental problems is discussed based on the collected data, discussions and informative activities. The groups discuss on the possible solution projects revealed in the process. The educator guides the groups in the development and implementing the group projects developed based on the group interests and requests.

4th Stage

After the projects are completed, each group presents the project. Groups assess each other and themselves. Assessments are discussed based on the group assessment form to determine what else could be done.

5th Stage

The groups design promotional activities about the measures to reduce the effects environmental problems due to human activities on living beings, and to transfer an environment without problems to future generations. Initially, each group selects a habitat, and designs promotional activities on the utilization of resources in this habitat to raise awareness about consumption and environmental problems. Groups share their

knowledge and projects with masses using the information and communication tools (internet, radio, television, newspapers, magazines, brochures, etc.).

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CHAPTER 4

DIGITAL STORYTELLING IN SCIENCE EDUCATION

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1. Introduction

Technological advances and employment of technology in education led to the development of methods that integrate technology into the course. New technological applications allow teachers and students to improve their knowledge and skills and raise educational standards (Smeda, 2014). Today, students want to be instructed by technological means. Digital storytelling is a modern, economic and easy to prepare application. Although storytelling is common in Turkey, the employment of digital storytelling in the classroom is less common (Karataş, 2020). Thus, the present chapter was authored to allow the teachers and pre-service teachers to employ digital storytelling in classes and acquire knowledge about digital storytelling.

2. Digital Storytelling

It could be observed that technology has constantly developed and provided conveniences in our lives (Pensky, 2001). The analysis of the changes in the phones, computers and several machines will demonstrate the developments over the course of history (Kayalı, 2018). Technology has led and continues to lead to several changes in the field of education, as it does in several other fields in our lives (Karakoyun, 2014; Baki, Yalçınkaya, Özpınar & Çalık Uzun, 2009). The employment of technological tools in education, the instruction of the topics and concepts shorten, and the associated costs are reduced (Küngerü, 2016). Also, technology allows the concretization and learning of abstract concepts in a shorter time, which otherwise could lead to confusion and makes the educational environment more fun (Turgut & Kışla, 2015). Recently, the classes should be fun, enjoyable and technological for the digital native students, who are proficient in social media and networks (Ulum & Ercan Yalman, 2018). The students do not have access to several technologies in the school environment; however, technology is prominent in their lives outside the school, leading to a conflict in the minds of the students (Uslupehlivan, Kurtoğlu-Erden & Cebesoy, 2017). Technology should be integrated into the curriculum to prevent the impact of this conflict on the success of the course and on daily life (Lambert, 2003). The integration of technological tools and novel methods and techniques with the instruction

would lead to a more enjoyable and interesting course, and academic achievements and productivity would improve (Sen, 2001; Hung, Hwang & Huang, 2012). Thus, the student's interest in school would be improved, the student would comprehend better, and student achievement would increase (Gömleksiz, 2004).

One of the best methods to integrate technology into the course is digital storytelling (Dorr, 2017). Digital storytelling is a modernized version of the classical storytelling tradition (Kajder & Swenson, 2004). Similar to classical storytelling, digital storytelling employs a unique perspective that is narrated to the audience (Abiola, 2014). Although digital storytelling has been employed abroad for a long time, it was introduced in Turkey only recently (Ulum & Ercan Yalman, 2018). Digital storytelling is the development and presentation of traditional stories on digital environments with audiovisual material (Figa, 2004). Digital stories allow the instruction of complex information within a short time (Sukovic, 2014).

The literature review revealed several definitions for digital storytelling. Digital storytelling entails the transfer of information or a story through media (Armstrong, 2003). Digital storytelling is the presentation of a story enriched with sound, music and pictures (Mellon, 1999). Digital storytelling associates the manuscript with multimedia material to orıvide information for the audience on any topic in any field (Robin, 2006). Digital storytelling is the development of the traditional storytelling method using several tools and technologies (Dreon, Kerper & Landis, 2011). Digital storytelling is the development of 3-5 minute videos that include text with verbal, visual and animated symbols available in the development medium (Tatum, 2009). Digital storytelling is the development of videos based on personal stories and the presentation of these videos on technological devices (Davis, 2002).

In late 1980s, the method employed by a theater company to record, produce and broadcast stories was adopted as digital storytelling by the literature (Lambert, 2003). Certain studies dated the concept back to early 1990s when the Center for Digital Storytelling was founded in Berkeley by Lambert and Dana Atchley (Chung, 2006). Between 1993 and 1994, Joe Lambert started to plan digital storytelling workshops with Dana Atchley (Kayalı, 2018). In 1994, Lambert's wife, Nina Mullen, Lambert and Lambert's colleague Atchley established the "Digital Multimedia Center" in San Francisco (Karakoyun, 2014). Lambert and his team developed several activity areas around the Digital Storytelling Center such as unique computer instruction spaces and an art program (Göçen, 2014). After the original center moved to San Francisco in 1998, Lambert and the team continued to study without any expectations. Since 2015, new educational environments were created, art and computer training programs were

developed, and they collaborated with a thousand institutions and trained thousands of individuals (Kutlucan, 2018).

Another such methodology is the Education 4.0 for digital storytelling (DS). Digital stories could be developed in all educational fields. For example, DS could be adopted for Portuguese, Geography, Mathematics, English, Physics, Sciences, Chemistry courses and all levels of education, including early childhood, elementary, secondary, and higher education.

3. Digital Storytelling Components

Seven elements guide digital story development (Lambert, 2003; Robin, 2006; Bull & Kajder, 2004): perspective, dramatic question, emotional content, use of voice, use of music, economy, and rhythm. These seven elements guide the author starting from writing the digital story script to the synthesis with digital materials (Göçen, 2014). In-classroom or digital presentations could be based on these seven components (Lambert, 2002).

Perspective: This element includes the main theme of the story and the perspective of the storyteller (Yüzer & Kılınç, 2015). This component determines the reason for telling the story and the point of view of the author, and the objective of writing the story (Robin 2008). The point of view should be clear for the audience (Lambert, 2003) and every part of the digital story should focus on the point of view and the multimedia tools should be selected accordingly (Bull & Kajder, 2004). For a clear point of view, the narrator needs to determine self-perspective and reflect on the reasons for selecting and developing the story (Lambert, 2010).

Dramatic Question: This is the question that would be answered at the end of the digital story and attract the interest of the audience immediately (Küngerü, 2016). Sometimes a question is used to raise the interst of the audience, and sometimes a graphic or image is used instead of a question (Bull & Kajder, 2004). The author should keep the focus on the story theme

when determining the question to sustain the interest, and the question should be formed to maintain the perspective (Göçen, 2014).

Emotional Content: This component entails the development of an emotional bond between the audience and the story with images, music and sound effects (Robin, 2008). When the digital story is played, this emotional bond should be observed in the gestures and mimics of the audience such as laughing, anger, sadness and tears, that reflect the establishment of the emotional bond (Kayalı, 2018). The story should be developed with multimedia tools that would touch and affect the audience emotionally and should be dubbed to reflect the desired emotion (Bull & Kajder, 2004). Thus, the message of the story would be internalized quickly by the audience (Lambert, 2003).

The Use of Sound: Digital stories allow the authors to narrate the scenarios they wrote (Öz, 2019). After the digital story is written, it is dubbed before it is presented to the audience to reflect the context of the story (Lambert, 2003). The author narrates the story to personalize it (Küngerü, 2016). The narration of the digital story should emphasize intonations and accents and could instil the desired emotions (Göçen, 2014). The narrator should adapt her/his voice based on the changing rhythm of the story, the pace and comprehension of the audience (Lambert, 2003). Thus, the use of sound further improves the effectiveness, meaningfulness and power of the digital story (Robin, 2006). It was argued that the storyteller's pitch and tonal variations personalize the narration of the meaning and purpose of the story (Bull & Kajder, 2004).

The Use of Music: Music makes the developed story more meaningful and adds depth to it (Kayalı, 2018). The music selected by the storyteller should be adequate for the topic, the meaning, the perspective, the objective, and the script of the story (Karakoyun, 2014). Adequate music adds emotion and empathy to the story and improves the power of expression (Arslan, 2013). Adequate music music adds further meaning to the story (Robin, 2006), supports and ornaments the story (Robin, 2008). The sound level and lyrics are as important as the song selection to prevent the suppression of the message by the music (Ciğerci, 2015). Thus, it would be adequate to use background music (Yüzer & Kılınç, 2015). Furthermore, music copyright should be considered in music selection (Lambert, 2003).

Economy (Brevity and Clarity): The economy component is where the digital story developers experience the biggest challenge (Lambert, 2003). They need to decide whether the images, sound effects and music in the digital story were consistent and adequate (Küngerü, 2016). The economy element does not only cover the length of the story text, but also the extent and quality of the employed multimedia material (Robin, 2008). When too many materials are employed in a long story, the audience may get bored

and distance themselves from the message (Kayalı, 2018). To avoid complexity and go beyond the aim of the story, the materials that are adequate for the story and express the point of view clearly should be employed (Bull & Kajder, 2004). To prevent deviation from the point of view, important visual and auditory material associated with the topic should be presented in the right order and in harmony (Lambert, 2010).

Rhythm (Speed Control): This element determined the speed of the progression of the digital story (Robin, 2008). A monotonous pace may prevent the focus of the audience (Bull & Kajder, 2004). A fast narrative may prevent the audience from following the story, a slown digital story would tire the audience and lead them to deep thoughts (Çakıcı, 2018). That is why the "speed control" is aptly names as the secret of a digital story (Göçen, 2014). The rhythm should be adjusted based on the story topic, the script, the characteristics of the audience, the content, and the flow of the digital story (Ertan Özen, 2020). The story should progress slowly in emotional and informative parts, the adventurous and exciting parts need to progress quickly (Lambert, 2003). There is a strong correlation between economy and speed control (Karakoyun, 2014). The digital story should have a natural speed and rhythm (Bull & Kajder, 2004).

The digital story elements include two groups. The four elements of perspective, dramatic question, emotional content and economy entail the stage of writing (story dimension), the contribution of sound, the use of music, and speed control elements are included in the production phase (digital dimension) (Bull & Kajder, 2004). Certain authors included the economy dimension in both the production and writing phases (Göçen, 2014).

4. Digital Storytelling in Education

Digital storytelling plays a key role in contemporary education (Balaman, 2016). Digital storytelling combines four significant strategies: student participation, reflection for in-depth learning, project-based learning and technology integration (Barrett, 2006). Digital storytelling is a popular method that provides in-depth and meaningful learning (Smeda, 2014). In-depth learning improves when students personalize digital story experiences (Sadık, 2008). Digital storytelling is an innovative and constructivist approach that allows analysis, generation of new ideas and products (Carey, 2009; Robin, 2008). These features are common requirements of science education. To produce higher quality products with the digital storytelling method, students and teachers should be actively involved in the process and employ technological tools (Heo, 2009). For a quality product, the story topic should be interesting, informative and important (Chung, 2006). The development of a digital

story appeals multiple senses and activates several cerebral functions, learning takes place faster and retained longer (Karakoyun, 2014).

Digital storytelling, which is a popular method that replaced traditional storytelling, has several additional benefits when compared to simple storytelling (Condy, Chigona, Gachago & Ivala, 2012). In digital storytelling, students could both have fun and acquire knowledge when they realize that they can use their skills in the digital environment (Dorr, 2017). Since the stories are developed and presented in a digital medium, student self-confidence increases with active use of digital media and the development of quality products (Ware, 2006). Since students feel like they are shooting a movie when producing digital stories, their motivation in the course improves and the course becomes more enjoyable and fun (Doğan, 2012). When students use technological devices and software, their digital literacy and fields of expertise improve (Demirer, 2013). When students create stories in digital media, they could express themselves more easily, select interesting topics, conduct research, write scripts and improve their sense of humor (Küngerü, 2016). Writing a story, sharing the story with peers, receiving feedback from them and evaluating the stories improve individual perspective (Chung, 2006). This contributes to the improvement of emotional intelligence and social learning, as well as academic achievement (Hung, Hwang & Huang, 2012).

The student presents her/his imaginary script on digital media with digital storytelling method and multimedia materials (Robin & Pierson, 2005; Robin, 2006). The students feel proud of themselves as they create a unique digital story based on creativity and imagination, contributing to self-learning (Öz, 2019). Digital stories allow the students to share their ideas without any limitations (Yeni, 2005). Students could share their digital stories on social networks and receive feedback from several individuals, and feel like an expert since they have proven themselves in a field and created a product (Kim & Li, 2020).

In the digital story development process, students are required to select a topic, conduct research on this topic, employ technological tools and software designed for digital story development, associate selected multimedia material with the text, and finally post the story on technological platforms (Kajder & Swenson, 2004). When students develop a meaningful digital story using images, music, sounds and texts, they demonstrate that the method could be employed at all grades and in every course, improving the 21st century skills of the students (Morra, 2013). 21st century skills generally include “digital literacy, global literacy, technology literacy, visual literacy, information literacy, creative thinking, effective communication and high productivity skills (Robin, 2008). In the 21st century, it is expected that students should ask questions, research, criticize, communicate, are information literate, have

responsibility and produce (Türkmen & Ünver, 2012). The analysis of digital storytelling would demonstrate that it could improve 21st century literacy or almost all 21st century skills (Jakes, 2006).

During the development of a successful digital story, a new product is created with the integration of video, images, sound effects and music in a digital story (Duveskog, 2012). The length of an ideal digital story should be less than 5 minutes, about 2-3 minutes (Doğan, 2007). A 2-5 minutes long digital story allows the student and the audience to watch it without any distraction or boredom (Kayalı, 2018). A digital story should include 15 still images and about 250-300 words (Kocaman Karaoğlu, 2015). Certain studies claimed that digital stories should be between 2-12 minutes, and the success of digital storytelling was determined by the adequacy of multimedia material and their impact on the audience (Ceylan & İlk, 2013). For a successful digital story, the music, lyrics, tone of voice, articulation, the number and quality of multimedia materials should be prioritized. Previous studies mentioned seven elements required to develop a successful digital story.

5. Digital Storytelling in Science Education

Science education plays a key role in the development of the nations and technology (Gölcük, 2017). Because the content and progress of science education is analogous with technological advances (Çiçek, 2018). The education system should be organized to train adequate number of individuals who can overcome problems and develop practical solutions, aware of contemporary and even future innovations, and science education is one of the cornerstones of this system (Karamustafaoğlu, 2006). In the age of technology, it is obvious that science and technology courses play a key role in the exponential increase in scientific knowledge and have a significant impact on every aspect of our lives, and technological advances never cease (Aydoğdu, 2006). Thus, due to the required qualifications in job applications, the quality of science education should be improved to train visionary, missionary and innovative individuals, who follow scientific and technological developments (Torun, 2016).

Technology is an essential requirement for individual (Çepni et al., 2005). Today, the technological advances in every field paved the way for the employment of technological devices and applications in the education system (Anılan, Berber & Anılan, 2018). The technology in the education system allows the students to effectively use all types of technological devices, equipment, software, and databases in scientific research (MEB, 2000). When the students learn to use technology effectively, they could easily transfer the knowledge learned at school to daily life, their interest and curiosity in the science course could improve, and they develop a positive attitude towards the science course (Akpınar, Aktamış & Ergin,

2005). The technology integration in classes allow the teachers to reach the students and improve their communication with the students (Titus, 2012).

The essence of science education is the complete instruction of scientific concepts to the students without any misconceptions (Akgün & Aydın, 2009). Inefficient instruction methods could lead to misconceptions (Driver, Guesne & Tibergihen, 1998). Several abstract concepts in the science course are difficult for the students to understand and could lead to misconceptions (Akgün, Gönen & Yılmaz, 2005). When this is the case, it should be identified and corrected as soon as possible (Gilbert, Watts & Osborne, 1982; Lawson, 1995). The employment of conventional methods could be inadequate in the elimination of misconceptions in the science course (Üce & Sarıçayır, 2002; Köse, 2004). Instead of the plain instruction of the science concepts and expecting the students to rote these concepts, audiovisual and permanent learning methods based on learning by doing and experiencing should be employed (Tahta, 2010). As the topics are instructed in the science course or as the students acquire the achievements, it is important to help them develop and use adequate methods and techniques for their level to achieve rich educational experiences (Doğan & Simsar, 2018). In science classes, students could explore the environment and access new information easily and meaningfully as they observe, communicate, estimate, and experiment (Akyol, 2016).

Science education guides the students in using and experiencing the learned knowledge in daily life (Akyol, 2016). When students discover the significance and intended use of the concepts instructed in the science course, their curiosity about the course increases (Şimşek & Çınar, 2008). School trips, experiments or videos ensure the curiosity of the students about nature, and they learn by discovering new data (Arı & Çelebi Öncü, 2005). When the students master a topic, they could see scientific cluse in several events in daily life and associate their knowledge with natural events (Uyanık, 2016). As the students associate the topics they learned at school with daily life, they see scientific phenomena in television images, a floating ship, and a hatching bird, and could explain these phenomena with science (Gürdal, 1992). When students can learn by doing or living and create their learning environment, knowledge becomes more permanent, students develop positive attitudes, which in turn is reflected in student behavior (Karamustafaoğlu & Yaman, 2010).

For active learning, the teachers should replace conventional methods with contemporary methods (Gölcük, 2017). The analysis of the recent exam data demonstrated that mean science course grades were low (Bilen, Hoştut & Büyükcengiz, 2016). Teachers do not employ contemporary methods or could not employ these methods efficiently (Titus, 2012). The employment of contemporary methods in the science

course increases student motivation, which in turn improves academic achievement (Yenice, Saydam & Telli, 2012). Motivation is effective and important in student achievement (Açıkgöz, 1996). Thus, every learning and teaching initiative should start with arousing an interest and curiosity among the students and at least maintain the excitement and motivation that students had at the beginning (Turgut & Kışla, 2015). Motivation of students in science education depends on various factors such as individual traits of the teachers and students, instructional methods and techniques, learning environment and the curriculum (Yılmaz & Çavaş, 2007).

With the development of several contemporary educational methods, digital storytelling, which has been commonly used and appreciated abroad and recently introduced in Turkey, could also be employed in science education (Hung, Hwang & Huang, 2012). However, the number of studies on digital storytelling in science education are limited (Hoban, Nielsen & Shepherd, 2015; Robin, 2016; Watts, 2007). The digital storytelling method provides several opportunities for both teachers and students (Kurudayıoğlu & Bal, 2014). Digital storytelling allows student development through the employment of images, music, sound effects and texts (Akgün & Akgün, 2020). Digital storytelling is also a novel approach that encourages the students and increase their motivation in training 21st century individuals (Morgan, 2014). Digital storytelling allows the concretization of abstract concepts in science education (Robin, 2008). Furthermore, it develops student's creativity, which is the building block of science education, as the student develops a script (Titus, 2012).

Digital storytelling method makes the science course more fun, contributing to student imagination, creativity, and the students spend a more fun time in the class (Gölcük, 2017). The employment of the digital storytelling method in the classroom is an effective method to facilitate the tasks of the teachers to maintain student concentration (Sadık, 2008). The students present their script drafts or stories to their peers and receive feedback, they consider these criticisms, edit their stories, improving their confidence in their works (Castañeda & Rojas-Miesse, 2012; Bandura, 1997). The students improve questioning, analysis and synthesis skills through self-criticism and the analysis of the criticisms, leading to a higher-level thinking (Ohler, 2008; Sadik, 2008; Ware, 2006; Turgut & Kışla, 2015). Higher-level thinking is important in science education (Bilen, Hoştut & Büyükcengiz, 2019). Thus, the student constructs knowledge, experiences in-depth learning takes and discovers self-learning (Çiçek, 2018). The digital storytelling method was preferred since it allows the integration of technology into the course at lower costs and shortens the learning time (Gils, 2005).

Since teachers and students collaborate in the development of digital stories, they assess the product in cooperation, expanding their

perspectives (Robin, 2016). Digital storytelling allows a student-oriented science education and allows the teacher to adopt the role of a guide (Hedderman, 2019). Peer assessments allow the students to help one another and transfer knowledge (Sadik, 2008). Students who actively participate in the class activities could engage in a respectful discussion, and even shy students would have the chance to express themselves (Banaszewski, 2005; Howell & Howell, 2003; Jakes & Brenan, 2005). Active learning also leads to permanence of the knowledge. Thus, the students would love the science course, preventing the stereotypes about complex and abstract concepts (Robin, 2008.)

One of the primary objectives of modern science education is to train science literate individuals (Akgün & Aydın, 2009). Science literate individuals are those who research and question, make effective decisions, solve problems, have high self-confidence, are open to cooperation, communicate effectively, and participate in lifelong learning with the awareness of sustainable development, and scientific knowledge, skills, positive attitudes, perceptions and values, understand the relationship between science and technology, society and the environment and associated psychomotor skills (MEB, 2013). The course should be instructed with contemporary methods to train science literate students, and the course content should be improved (Gürsoy, 2021). Science literate individuals should possess active creativity, critical thinking, entrepreneurship, scientific process and life skills (UNESCO, 2010).

The digital storytelling process includes several stages, namely personal, informative and historical storytelling (Haliloğlu Tatlı, 2016; Kahraman, 2013; Karakoyun, 2014; İnceelli, 2005). In the digital storytelling process, the subject is determined, a script is written, and a storyboard is drawn. Research is conducted, adequate materials are determined, digital stories are developed and shared on a technological medium (Jakes & Brennan, 2005) Thus, the students would acquire several skills required in science education such as problem solving, analysis, hypothesizing, testing, decision making, articulation, and daily life skills. When the individual combines the scientific concepts, the technological platform and multimedia materials, the individual would not only be proud about creating an original work with technological tools, but also learn the topic and retain the knowledge permanently (Karataş, 2020). Similarly, it would lay the foundation for technology literacy, media literacy and visual literacy, which are among the objectives of science education (Robin, 2006). In a study on the effects of digital storytelling with STEAM, Silva et al. (2019) reported that it helped students develop their creativity, scientific reasoning, teamwork, and problem-solving skills. It was argued that the stages of STEAM and digital storytelling were similar processes. It was revealed that the stages such as research conducted to determine the

content and limits of the story, explorations conducted during scripting, collecting data from the media, and establishing connections during the development of the story, creating, recording and sharing the digital storytelling product, and receiving feedback served the acquisition of similar skills.

The literature review on studies about digital storytelling in science education revealed that the number of studies conducted with pre-service teachers and students was higher when compared to that of the studies conducted with teachers. Furthermore, the number of studies that aimed to determine the effect of digital storytelling on academic achievement, attitudes and motivation was quite high. Karataş (2020) investigated the impact of digital storytelling on academic achievement and permanence in science education. Yıldız Çelik (2021) studied the effect of digital storytelling on academic achievement and 21st century skills in science education. Nam (2017) conducted a study on the impact of digital storytelling on academic achievement, social presence and attitudes in science education. The review of the above-mentioned reports demonstrated that digital storytelling had positive effects on science education. In science education, most students have stereotypes about the science course; however, it was observed that the employment of digital storytelling in the science course could eliminate these student stereotypes and allows the latter to develop positive attitudes. The employment of digital storytelling in the science course easily motivates the students, improving the academic achievements. The consideration of these three correlated variables (attitude, achievement and motivation) aims the adoption of the digital storytelling method by the teachers, to sustain positive student attitudes, increasing their motivation for the science course, and ultimately academic achievement.

5.1. The impact of digital storytelling in science course on motivation

Motivation is a determinant in many aspects of life, as well as education (Uyanık, 2016). Increasing the motivation for the science course activities would contribute to learning (Kuhn & Müller 2014). Factors such as the form, location, organization and temperature of the educational environment affect motivation (Ali, 2009). The materials, methods and techniques employed in the instruction and the educational environment are contemporary and effective methods that facilitate learning (Yang & Wu, 2012). Goulah (2007) conducted a study on the impact of digital storytelling on student motivation with a qualitative approach. Field notes, diaries, verbal and written feedback, and open-ended questionnaires were employed to collect the data. The study aimed to determine its effects on both individual the collaborative learning of the students. Goulah conducted the study as a research teacher. Ulusoy (2019) investigated the

impact of the digital storytelling method in science course on motivation, attitude and academic achievement of 42 7th grade students. An interview form, achievement test and a scale were employed as data collection tools. The study findings revealed that student motivation for the science course increased. It was observed that they developed positive views on the course and their academic success improved.

5.2. The impact of digital storytelling in science course on academic achievement

In Turkey, it could be observed that the achievements of the students are quite low in science, similar to other fields (Bilen, Hoştut & Büyükcengiz, 2019). The employment of new and effective methods/techniques in the science course would improve student involvement, provide an environment where students could learn by doing and living, and change their perspectives on the course, leading to an increase in student achievements in science (Korucu, 2020). Furthermore, attitude (Karamustafaoğlu & Yaman, 2010) and motivation (Uyanık, 2016) affect achievement. Digital storytelling positively affects academic achievement and was recommended by scholars (Yüksekyalçın, Tanrıseven & Sancar-Tokmak, 2016). Francis (2018) conducted a study with 42 male subjects and mixed method. Students were assigned to four achievement levels. The a investigated the student achievement levels at the end of the process. The study data were collected with a two-stage test, a questionnaire and focus group interviews. The study findings revealed that there was a significant difference between academic achievements.

Karataş (2020) investigated the impact of digital storytelling method on academic achievement and permanence in the science course in a quasi-experimental study conducted with 3rd grade students. The study participants included 54 students attending a primary school in Ankara, Turkey, where the experimental group included 26 and the control group included 28 students. The data were collected with a semi-structured interview form and the science achievement test (SAT) that included 32 questions developed by the author. The findings of the study that lasted for 6 weeks demonstrated that the digital storytelling method affected academic achievement and permanence. Ulum and Ercan Yalman (2018) conducted a study with eight 8th grade students, who spent excessive time on the computer. The academic achievements of these students were low. Digital storytelling method was employed in the instruction of the students who spent excessive time on the computer and were computer literate to raise their interest in education, the science course, and academic achievement. A semi-structured interview form and achievement test were used as data collection tools. The findings revealed that the science achievements of the students and their interest in the science course improved. The students stated that they liked the digital storytelling

method, and it was a fun process. The authors followed these findings with certain recommendations.

5.3. The impact of digital storytelling in science course on student attitudes

Rote-based conventional instruction of the science course could lead to negative student attitudes towards the science course (Turgut & Kışla, 2015). To prevent cognitive and affective difficulties in further education, the student should acquire positive attitudes towards science at an early age (Yaşar, 1993). Attitude is a factor that affects student learning and comprehension (Uyanık, 2016). Teachers should adopt methods that would lead to learning by doing-living for effective learning at school, permanence of the knowledge, and the acquisition of positive attitudes by the student that would in turn would be reflected in course achievements (Karamustafaoğlu & Yaman, 2010). Methods and techniques that develop creativity help positive student attitudes towards science (Davaslıgil, 1984). Since digital storytelling provides creative opportunities, students develop positive attitudes towards the science course (Gömleksiz & Pullu, 2018).

In a study conducted with 6th grade students, Torun (2016) investigated the effect of digital storytelling employment in the science course on student attitude and academic achievement with a mixed method approach. The study data were collected with the Cell Concept Test, Scientific Process Skills Scale and Science and Technology Attitude Test, and a semi-structured interview form. The study findings demonstrated that academic achievements and attitudes of the experimental group was higher, and the method was recommended to teachers. Büyükcengiz (2017) analyzed the impact of the digital storytelling method on academic achievement, scientific process skills and attitudes of the students towards the science course. The study was conducted with 60 6th grade students. The Earth, Moon and Sun, Source of Life Achievement Test, Scientific Process Skill Test, Attitude Towards Science Course Scale, and a semi-structured interview forn were used as data collection tools. The study data revealed that the students developed a positive attitude towards the science course and an increase was observed in their academic achievements.

6. Conclusion

Digital storytelling in science education is a contemporary approach that teachers and pre-service teachers should learn. The method improves student achievements in the science course. It was observed that digital storytelling could be implemented with various age groups, in different educational levels, and on different topics. Digital storytelling could be employed to concretize the abstract concepts in the science course. Digital storytelling could improve student motivation for science and encourage

them to learn the next topic. The analysis of the effects of digital storytelling on students revealed that teachers who want to achieve real achievements in science education should learn to develop digital stories and employ technological software.

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CHAPTER 5

A NEW ENVIRONMENTAL EDUCATION APPROACH: ENVIRONMENTAL EMOTION-ENHANCED ACTIVITIES*

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1. Introduction

Our emotions play a key role in the development of important environmental behavior during education process (Gosling & Williams, 2010). Our direct relations and experiences with the environment have profound emotional effects on human nature and behavior. It should be remembered that this leads to a deeper individual commitment to nature and a high interest in environmental conservation (Restall & Conrad, 2015). Environmental attitudes are associated with the belief that individuals are a part of the natural environment (Schultz, Shriver, Tabanico & Khazian, 2004). When individuals feel connected to nature and know that they are a part of nature, they are less likely to cause environmental problems. Because they would know that harming nature would mean self-harm (Mayer & Frantz, 2004).

The development of environmental emotions and ideas to protect the environment in individuals is more important than enacting laws and regulations to protect the environment (Öztürk, 1998). Individuals without environmental emotions could not adopt positive environmental behaviors. Thus, environmental education in educational institutions should include environmental emotions rather than adopting conventional instruction techniques. Furthermore, it is known that individuals who value the natural environment and are concerned about protection of nature would protect nature better. Although individuals are educated from pre-school age to higher education, the environmental sensitivity of individuals is still not at a desired level, indicating the problems in the development of environmental emotions during education (Aksoy & Karatekin, 2011). Thus, environmental education, described as the improvement of environmental awareness in the society, development of permanent environment-friendly attitudes and behavior, aims to train individuals who

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are sensitive to environment, aware of environmental problems and seek solutions to these problems when required (Onder & Kocaeren, 2015).

The traditional approach based on the belief that environmental education would lead to changes in the environmental behavior of individuals through the instruction of basic theoretical environmental knowledge is considered inadequate (Hungerford & Volk, 1990; Schultz, 2002). Because our modern environmental problems are significantly intertwined with our personal relationship with nature (Liefländer, Fröhlich, Bogner & Schultz, 2013). Thus, components of individual environmental literacy (skills, affective orientations, attitudes and responsible environmental behavior) and certain components that predict the development of behaviors by knowledge have been emphasized (Aydın, Doğan & Başlar, 2007; Arkonaç, 2005; Schultz et al., 2004). It is clear that to resolve the current environmental problems, it is necessary to train individuals who are aware of these problems and could take the required initiatives. Raising individual awareness about the environment could increase the number of environmentally literate individuals. Thus, various environmental courses are instructed in educational institutions between pre-school period and higher education. This indicates the significance of the current environmental education.

The "inclusion with nature" concept introduced by Schultz (2002) is a psychological analysis of the human-nature relations. Thus, the state of inclusion with nature has cognitive, affective and behavioral dimensions. The cognitive aspect includes commitment to nature, the affective aspect includes concern about nature, and the behavioral aspect includes commitment to the natural environment. Based on this psychological analysis, Carmi, Arnon & Orion (2015) developed a structural equation model. This model briefly posits that environmental emotion is a significant predictor of environmental behavior.

In the present study, enhanced activities include connectedness with nature, biospheric environmental concerns and commitment to the natural environment dimensions, which are the subcomponents of environmental emotions, are introduced. The activities were developed based on the "inclusion with nature" approach proposed by Schultz (2002) and the conceptual framework validated by the structural equation model by Carmi et al. (2015). It could be suggested that the introduction of environmental emotion-enhanced activities enriched with environmental emotion components in the current study would be an original contribution to the literature.

2. Inclusion with Nature

The conceptual framework of inclusion with nature was described by Schultz (2002, pp. 61-78) as follows:

Inclusion, which is a psychological analysis, focuses on the individuals' comprehension of their place in nature, the value they attribute to nature, and the effects of individuals' actions on the natural environment. Inclusion with nature includes three main components: "connectedness, concern and commitment" (Schultz, 2002).

Connectedness with Nature

The concept of "connectedness" reflects the relationship between individuals and the environment from a philosophical and sociological point of view. The focus is on how much the individual believes to be a part of the natural world. In several philosophical and sociological theories on the relationship between individuals and the environment, the term "connectedness" has been used to describe the extent of individual belief that they are part of nature. Connected with nature is a cognitive state, although it has been used in a broad context. It indicates to what extent the individual is connected with nature. Individuals who express themselves as a part of nature are significantly consistent with nature in their cognitive structures. (Schultz, 2002).

Caring for Nature

The second dimension of inclusion with nature is affective. This dimension is associated with the degree that the individual cares for nature, in other words, the individual's feeling of intimacy. This emotion includes sharing and a deep level of knowledge. This emotion of intimacy could provide self-discovery, as well as sensitivity for other living organisms and nature. It could be suggested that emotional intimacy has an important effect on the development of responsible environmental behavior due to the positive interaction with and spending time in nature. Thus, it is possible to think about our relationship with nature as a social relationship. Relationships become more intimate when parties spend more time together. Relationship with nature is similar (Schultz, 2002).

Commitment to Protect Nature

The third dimension of connectedness with nature is behavioral. It could be observed that individuals are motivated for nature-friendly behavior when they are connected with nature and value nature. The dedication in interpersonal relations means that there is a desire to maintain the relationship and to allocate resources and time for it. It could be suggested that this is similar in the relations between individuals and nature (Schultz, 2002).

There is a causality between the above-mentioned three basic components of connectedness with nature. Individuals who are connected with nature are concerned about nature. Individuals who are concerned about nature are committed to protecting nature. In other words, those who

are connected with nature at a cognitive level are concerned about nature and more willing to conduct environmental behavior (Schultz, 2002).

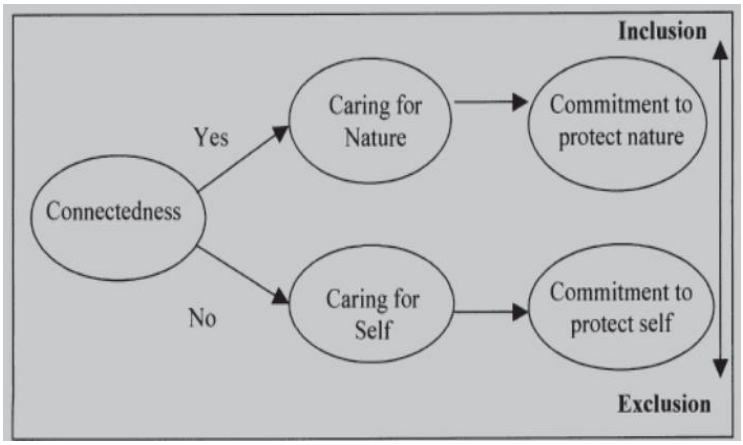


Figure 1: The basic components of connectedness with nature and correlations between these components (Schultz, 2002).

The prevention of the inclusion of the individual in the nature by the actions of the individual could be associated with certain specific environmental behavior. In other words, this could be due to the commitment to self-protection. Individuals with a low inclusion with nature could prioritize self-protection rather than protecting nature such as recycling to save money, using vehicles with low fuel consumption to spend less (Schultz, 2002).

3. Environmental Emotions

Inclusion in nature and the relations between individuals and nature have been discussed in a theoretical framework. In this framework, connectedness with nature was conceptualized to include three components. Carmi et al. (2015), on the other hand, included emotions from a predominantly affective approach into this conceptual framework. Based on the findings reported by previous studies, it was suggested that the differences between the concept of environmental emotion and inclusion in nature were negligible, and these two concepts could be considered as synonymous. Thus, the concept of inclusion in nature could be considered equal to the concept of emotion with slight differences. To understand this theoretical framework better, Carmi et al. described the emotions that reflected inclusion in nature as "environmental emotions". Furthermore, they revealed that individuals should develop environmental emotions for the transformation of environmental knowledge into behavior. The concept of environmental emotion includes the sub-dimensions of connectedness with nature, biospheric environmental concern, and commitment to the natural environment. Connectedness with

nature is an affective dimension that develops outside of the latent and cognitive awareness, and reflects the associations between individuals' emotions and the environment. Biospheric concern characterizes individual beliefs about environmental problems and includes the human concerns about all other living species. The dimension of the commitment to protect nature reflects the commitment of individuals to the natural environment (Carmi et al., 2015). These dimensions are presented in Figure 2.

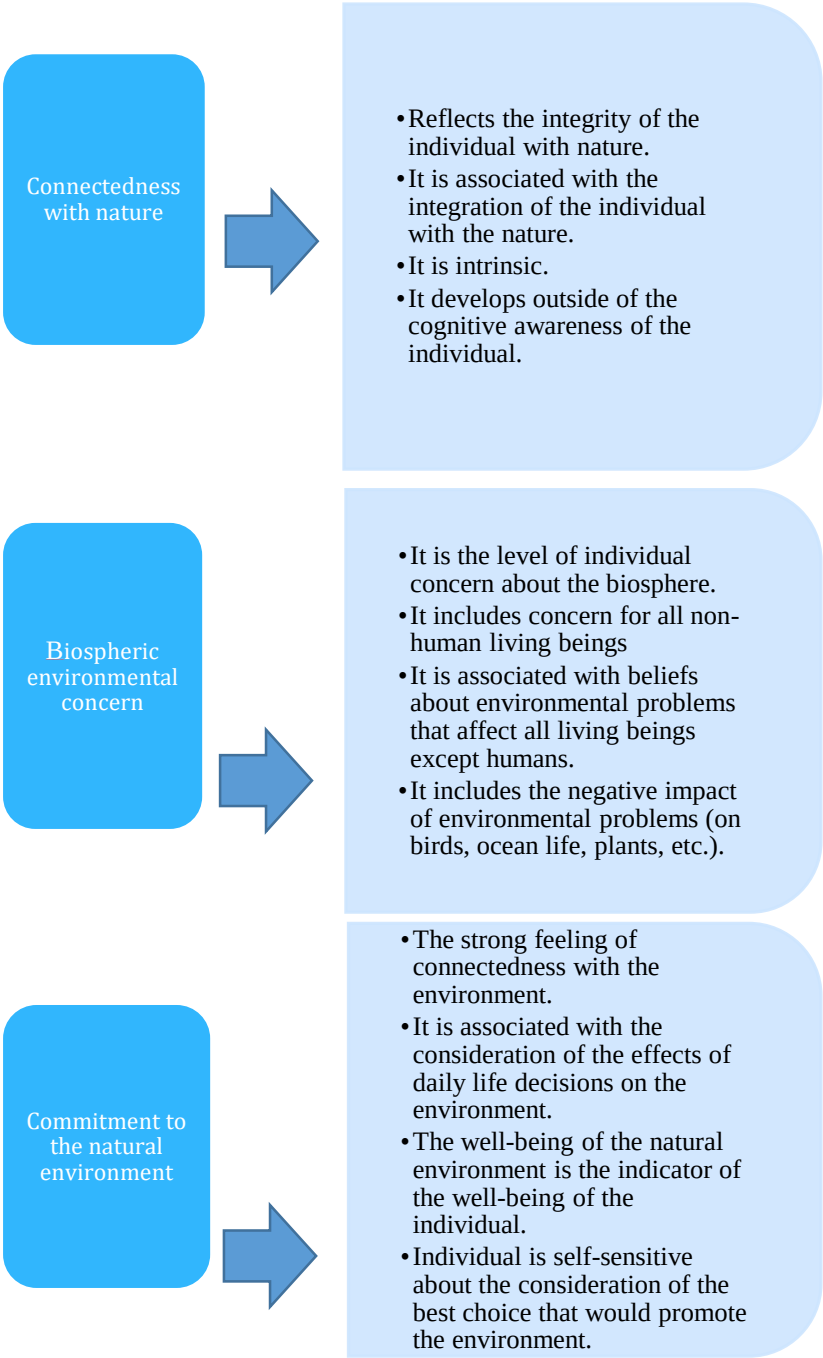


Figure 2: Sub-dimensions and properties of environmental emotion (Carmi et al., 2015)

Carmi et al. (2015) reported that environmental emotions are a significant predictor of the transformation of the objective and subjective individual knowledge on the environment into environmental behavior. They tested this with the structural equation model. The model is presented in Figure 3.

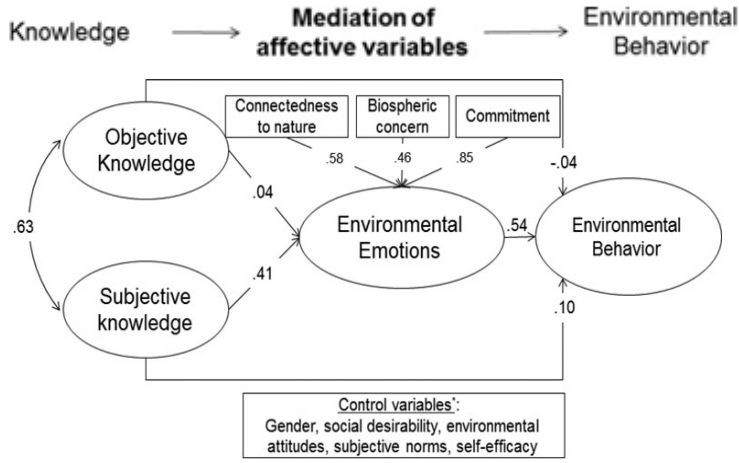


Figure 3: The correlation between environmental emotions and knowledge-behavior (Carmi et al., 2015)

As seen in Figure 3, the environmental emotion factor has a significant effect on the transformation of environmental knowledge into environmental behavior. Also, Carmi et al. reported that subjective and objective knowledge has an insignificant direct effect on the development of environmental behavior. In particular, it was observed that both objective and subjective knowledge do not directly affect environmental behavior. However, it was determined that environmental emotions have a significant (0.54) direct impact on environmental behavior.

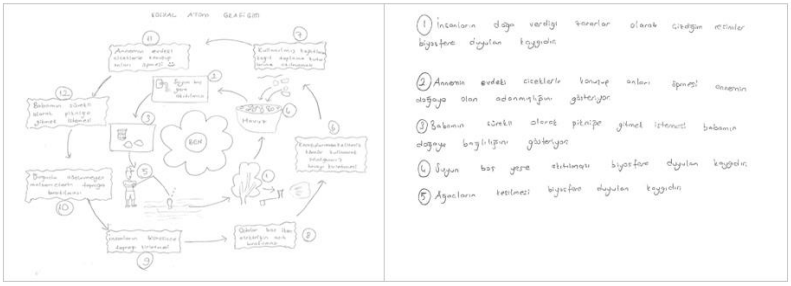
4. Environmental Emotion-Enhanced Activities

Our emotions are important determinants of our beliefs, attitudes and values. Our emotions also shape our affective relations with the environment (Myers, 2007). Studies that investigated the conceptual framework of environmental emotions and emotion revealed that our emotions and sensations play a key role in environmental behavior (Davis, Green & Reed, 2009; Kals, Schumacher & Mondata, 1999). It could be suggested that environmental awareness has a significant effect on environmental behavior, and individuals with positive emotions about the environment would exhibit more environmental behavior. Thus, it could be suggested that individuals with a sense of connectedness with the environment and reflect this connection in cognitive structures are more willing and dedicated to exhibit pioneering environmental behavior. The

environmental emotion-enhanced activities were developed for this purpose in the current study. Based on the above-mentioned framework, the activities were organized to include environmental emotion subcomponents such as connectedness with nature, commitment to the natural environment and biospheric concern. The activities were developed to ensure the implementation in the inquiry-based, student-centered and active learning process with collaborative reflection groups based on the constructivist approach. Sample activities are presented below.

4.1. "Let's Draw a Social Atom" Activity

This activity aims to raise awareness about the patterns associated with significant individuals, situations, events, phenomena and institutions that support the development of individual emotions about the environment (connectedness with nature, biospheric concern, commitment to nature) and individuals feel close to. The activity includes two stages. **First stage**: In the activity, the individual is asked to draw an atom centered on the individual. The individual is asked to draw the orbits or levels of the atom freely. Thus, levels are formed starting at the center that reflects the individual. Before drawing the social atom, the individuals should be informed about environmental emotions and sub-components, connectedness with nature, biospheric concern, and commitment to the natural environment dimensions as detailed in the present study. Individuals are instructed as follows: "What are important in the development of your emotions about the environment? Reflect on it and evaluate their accuracy. And list the important people, institutions, organizations, events, books, etc. for you by placing yourself in the center (similar to the solar system) and placing the rest on their own orbits and indicate why they are important for you. Note that the most important ones should be in the orbit closest to the center, the less important ones should be in the more outer orbits in order of importance. Your social atom drawing will be completely unique. You can use any image, symbol, shape, text, expression you want." Then, the participants are asked to write the connectedness with nature, biospheric concern, and commitment to the natural environment titles on the back of the same page. Under these titles, they are asked to group the concepts in orbit in the social atom drawing under the related dimension. **Second stage**: After the participants complete the social atom drawing, they are asked to show and explain these to the other participants and express their emotions about their own drawings. The activity ends with a discussion about the classification of the orbits under connectedness with nature, biospheric concern, and commitment to the natural environment.



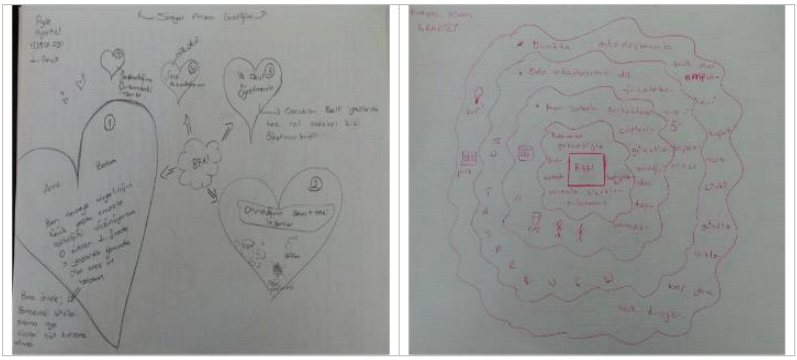
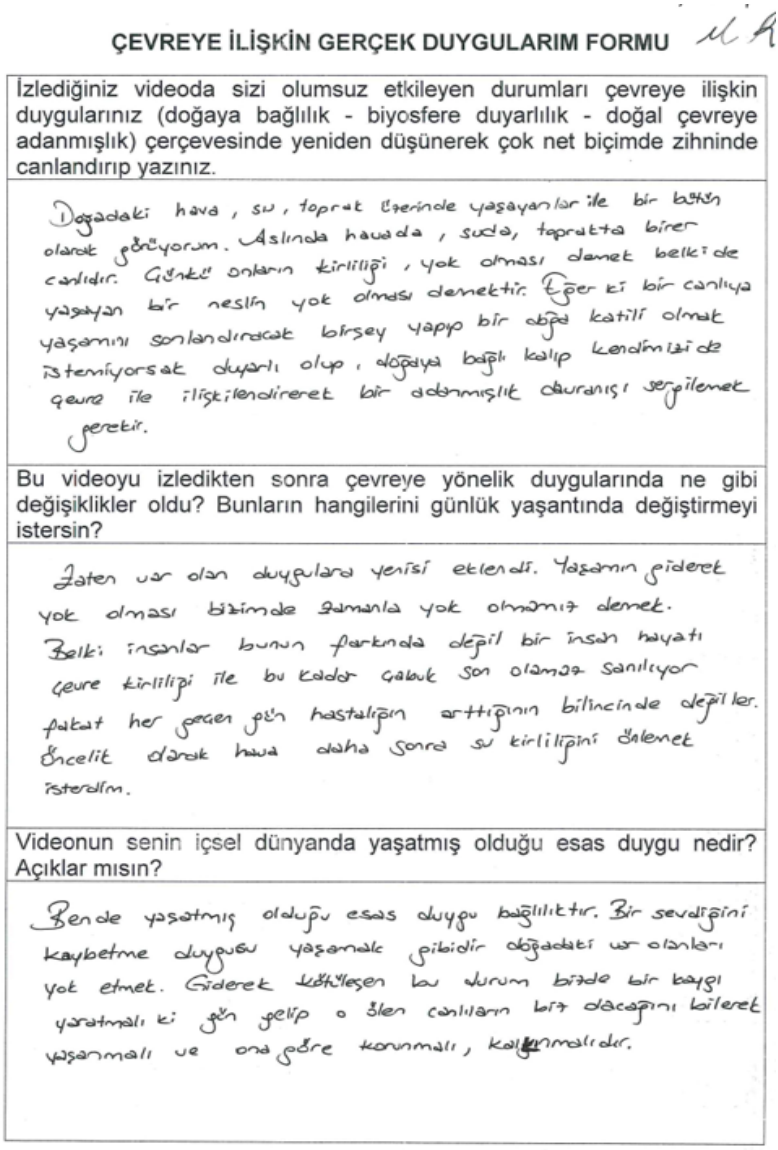


Figure 4: Sample “Social Atom” Drawings

4.2. “My real feelings about the environment” Activity

In this activity, participants first watch a video about the causes and consequences of environmental pollution. The video may include themes such as elements that threaten the life of living beings, injured life, the damaged natural environment, sustainable life, significance of water etc. Before the activity, the individuals should be informed about environmental emotions and sub-components, connectedness with nature, biospheric concern, and commitment to the natural environment dimensions as detailed in the present study. After watching the video, the participants are asked to fill out the “My Real Feelings About the Environment” form, which includes three sections. **In the first section**, the participants are asked to reconsider the situations in the video that affected your emotions about the environment negatively (connectedness with nature, biospheric concern, and commitment to the natural environment), re-imagine them in detail, write them down in the area provided. **In the second section**, they were asked to answer the following question: “What were the changes in your environmental emotions after watching the video? Which of these would you like to change in your daily life?" **In the third section**, they are asked the following question: “What is the main

emotion that the video evoked? Please elaborate" Then, the participants are asked to state their views and emotions on the form. In this stage, the activity is terminated with a discussion on environmental emotion dimensions, namely connectedness with nature, biospheric concern, and commitment to the natural environment.



ÇEVREYE İLİŞKİN GERÇEK DUYGULARIM FORMU

İzlediğiniz videoda sizi olumsuz etkileyen durumları çevreye ilişkin duygularınız (doğaya bağlılık - biyosfere duyarlılık - doğal çevreye adanmışlık) çerçevesinde yeniden düşünerek çok net biçimde zihninde canlandırıp yazınız.
Doğadaki hava, su, toprak üzerinde yaşayanlar ile bir bütün olarak görüyorum. Aslında havada, suda, toprakta birer canlıdır. Çünkü onların kirliliği, yok olması demek belki de yaşayan bir neslin yok olması demektir. Eğer ki bir canlıya yaşamını sonlandıracak birşey yapıp bir dağa katili olmak istemiyorsak duyarlı olup, doğaya bağlı kalıp kendimizi de çevre ile ilişkilendireret bir adanmışlık duranışı sergilemek gerekir.
Bu videoyu izledikten sonra çevreye yönelik duygularında ne gibi değişiklikler oldu? Bunların hangilerini günlük yaşantında değiştirmeyi istersin?
Zaten var olan duygulara yenisi eklendi. Yaşamın giderek yok olması bizimde zamanla yok olmamız demek. Belki insanlar bunun farkında değil bir insan hayatı çevre kirliliği ile bu kadar çabuk son olamaz sanılıyor fakat her geçen gün hastalığın arttığının bilincinde değiller. Öncelik olarak hava daha sonra su kirliliğini önlemek isterdim.
Videonun senin içsel dünyanda yaşatmış olduğu esas duygu nedir? Açıklar mısın?
Bende yaşatmış olduğu esas duygu bağlılıktır. Bir sevdiğini kaybetme duygusu yaşamak gibidir doğadaki var olanları yok etmek. Giderek kötüleşen bu durum bizde bir bayağı yaratmalı ki gün gelip o ölen canlıların bitt olacağını bileret yaşanmalı ve ona göre korunmalı, kollanmalıdır.

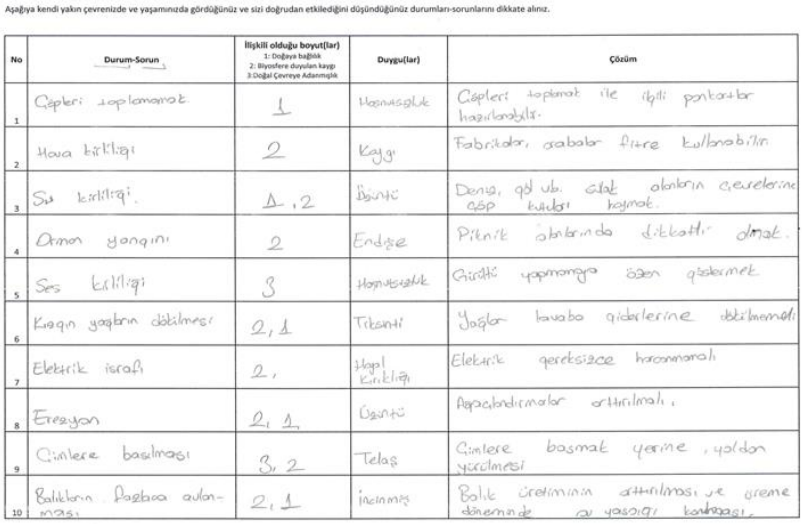
Figure 5: Sample “My real feelings about the environment” Form

4.3. "Situation-Problem & Emotion-Solution" Activity

In this activity, an activity form is distributed. The form included four sections. **In the first section** (*Situation-Problem*), the participants are asked to think about the situations and problems that they experienced in daily life that directly affected them and write about this problem. **In the second section** (*Related Dimension*), they associate the situation-problem they mentioned and an environmental emotion component (connectedness with nature, biospheric concern, and commitment to the natural environment), and **in the third section** (*Emotion*), the participants are asked to write about the emotion that the above-mentioned situation-problem evoked in them. **In the fourth section** (*Solution*), the individuals are asked the following question: "What kind of solution would you suggest for the situation-problem based on the dimensions you associated with the problem and your emotions?" The activity ends with a discussion on the views addressed in the forms.

Aşağıya kendi yakın çevrenizde ve yaşamınızda gördüğünüz ve sizi doğrudan etkilediğini düşündüğünüz durumları-sorunlarını dikkate alınız.

No	Durum-Sorun	İlişkili olduğu boyut(lar) 1: Doğaya bağlılık 2: Biyosfere duyulan kaygı 3:Doğal Çevreye Adanmışlık	Duygu(lar)	Çözüm
1	Arkadaşlarımın kendi benzerlikleri için dünyaya katıtmaukları paraflimeri ürünleri.	Biyosfere olan kaygı	Hüzün verici	Olmazdan gelmeyince uyarmak veya daha az durumuna müdahale etmek
2	Babamın bağı, bahçesi, tarlayı çevre için ekipme malzemi olarak görmesi	Biyosfere kaygı	Acı bi durum	Babamı bu durumdan bilgilendirmek ve doğayı para ile ilişkilendirilmeyeceğini vurgulamak.
3	Bütün yıl çamaşır yıkadığımız çamaşır suyu fakat kullanmamaya karar verdim.	Doğal Çevreye olan Adanmışlık	Mutluluk, +	Toprağımda, suyumda, diğer canlılarımda bu şekilde korumaya olur.
4	Dersteki yaşayan varlıkları yine para için geleceği düşünmemek, vurulması.	Biyosfere olan kaygı	Hüzün verici	Devletin daha ağır cezalar uygulaması ancak bu durumu azda olsa durdurulabilir.
5	Çöplük kokusu ve çöplerdeki ağır ilkmeye ve bakımına tesfuk etmeye çalışalım.	Doğaya Bağlılık	Mutsuzluk.	Geleceği koruma altına almak. Onların da kendilerden sonrakilere bunları öğretmesi
6	Doğanın bozulması sadece insanlar değil en küçük organizmaları da etkiler.	Biyosfere olan kaygı	Hüzün	Bu olaya tanımış, sözü dinlenen kişiler tarafından farkındalık yaratmak.
7	Hayvanın bazen kendileri için bazende biter için aşırı derecede çöplük çıkıntıyalım	Biyosfere Olan kaygı	Öfke Acı verici	Bunlar daha ona inanmak ve sadece o an için birleş düşünmek yerine bakalım...
8	Kendini bilmezlerin karşısına, bahçede... yere tükürmesi	Doğaya Bağlılık	Öfke Üzülme	Uyarmak, tepki göstermek ve üzücü bir durum olduğunu göstermek.
9	Marka takıntısı olan annem ve yengemin gerçek deri ve kürk kullanması	Biyosfere kaygı	Hoşnutsuzluk	onları bu durumdan uyarmak ve o canlıya nasıl acı çektiğini göstermek...
10				



Aşağıya kendi yakın çevrenizde ve yaşamınızda gördüğünüz ve sizi doğrudan etkilediğini düşündüğünüz durumları-sorunlarını dikkate alınız.

No	Durum-Sorun	İlişkili olduğu boyut(lar) 1: Doğaya bağlılık 2: Biyosfere duyulan kaygı 3:Doğal Çevreye Adanmışlık	Duygu(lar)	Çözüm
1	Çöpleri toplamamak	1	Hoşnutsuzluk	Çöpleri toplamak ile ilgili pankartlar hazırlanabilir.
2	Hava kirliliği	2	Kaygı	Fabrikalar, arabalar filtre kullanabilir
3	Su kirliliği.	1, 2	İsyankâr	Deniz, göl vb. sulak alanların çevrelerine çöp kutuları koymak.
4	Orman yangını	2	Endişe	Piknik alanlarında dikkatli olmak.
5	Ses kirliliği	3	Hoşnutsuzluk	Gürültü yapmamaya özen göstermek
6	Kızgın yağların dökülmesi	2, 1	Tiksinti	Yağlar lavabo giderlerine dökülmemeli
7	Elektrik israfı	2,	Hayal kırıklığı	Elektrik gereksizce harcanmamalı
8	Erozyon	2, 1	Üzüntü	Ağaçlandırmalar arttırılmalı.
9	Çimlere basılması	3, 2	Telaş	Çimlere basmak yerine, yoldan yürümesi
10	Balıkların Ölçüsüz avlanması	2, 1	İncinmiş	Balık üretiminin arttırılması ve üreme döneminde av yasağı konulması.

Figure 6: Sample “Situation-Problem & Emotion-Solution” Forms

4.4. “Environmental Emotion Scenarios” Activity

In this activity, participants read a text that aims to stimulate their environmental emotions. Before the activity, the individuals should be informed about environmental emotions and sub-components, connectedness with nature, biospheric concern, and commitment to the natural environment dimensions as detailed in the present study. After they read the text, the participants are provided with the "Environmental Emotion Scenarios Activity" form. The form includes three sections. The first part is named “His/Her Emotion,” the second part is named “My emotion,” and the third part is named “Including Yourself.” Participants are asked to consider the instruction on the activity form. In accordance with the given instruction, they are asked to read the statements in the text and to think of themselves as the person who hears them. In the first section, they are asked to write the most intense feelings of the person who stated these. In the second part, they are asked to write their own feelings about the person who stated these. In the final part, they are asked to write their self-inclusion statement based on the whole case. The activity ends with a discussion on the views addressed in the forms

Sample "Environmental Emotion Scenarios" Activity Form:

SENARYOLAR FORMU

Aşağıda yer alan ifadeleri okurken kendinizi bunları işiten kişi yerine koyunuz. Bir dinleyici olarak ilk kısma, paylaşan kişinin en yoğun duygusunu, ikinci kısma söylediklerine ilişkin kendi duygunuzu ve üçüncü kısma kendinizi katma cümlenizi yazınız.

Doğa Düşmanlığı

"Doğayla bağınızı kaybederseniz, insanlıkla da bağınızı kaybedersiniz. Doğayla hiçbir ilişkiniz yoksa, zamanla katile dönüşürsünüz; yavru fokları, balinaları, yunusları, insanları çıkar için, "spor" olsun diye, yiyecek için ya da bilgi için öldürürsünüz. O zaman doğa sizden korkar, güzelliklerini geri çeker. Ağaçlar arasında uzun yürüyüşlere çıkabilir, hoş mekanlarda kamp yapabilirsiniz, ama yine de bir katilsinizdir, dolayısıyla o güzelliklerle dostluğunuzu kaybedersiniz

Büyük bir olasılıkla hiçbir şeyle, karınızla ya da kocanızla ilişkide değilsiniz; hep kendi özel düşüncelerinizle, zevklerinizle, acılarınızla uğraşırsınız. Kendi karanlık, soyut dünyanızda yaşarsınız, buradan kaçış yolunuz daha da koyu karanlıktır. İlgi alanınız umursamaz, kolaycı ya da şiddet dolu kısa bir yaşam sürmektir. Sizin sorumsuzluğunuz nedeniyle binlerce insan açlıktan ölür ya da kıyıma uğrar. Dünyanın düzenini yalancı, ahlaktan yoksun siyasetçilere, entelektüellere, uzmanlara bırakırsınız. Kendi içinizde bütünlüğünüz olmadığı için ahlaktan ve dürüstlükten yoksun, yalnızca bencillik üzerine temellenen bir toplum kurarsınız. Sonra da yalnızca sizin sorumlu olduğunuz bütün bu şeylerden deniz kıyısına ya da ormana kaçar ya da "spor" yapmak için silah taşırsınız. Bütün bunları biliyor olabilirsiniz, ama bilgi dönüşüm yaşamamızı sağlamaz. Ancak bütünlük duygusuna sahip olduğunuzda evrenle ilişkide olabilirsiniz." Jiddu Krishnamurti - Doğa Düşmanlığı

Onun duygusu

.....Doğaya...karşı.....olan...duygusuzluk...İnsanı...bir....katile...dönüştürebileceğini
...gösterektedir....İnsanın...evrenle....ilişkili...olduğunu....bilmemesi.....
..zamanla.....hem...kendisine...,hem...etrafındakilere.....hem de....evrensine...
....olan...bencillikte....dönüşür.....

Kendi duygum

.....Eğer...insan...bilinçli....bir....şekilde....evrenin....farkında....olursa.....
..doğanın....yanısı...,....ağacı...,...kıtayı"....nabatlıkla....gösterebilir...İnsanlığa...
..ve....doğaya...da.....olan....bağını...koruyabilmek.....
.....

Kendini Katma

.....Evren...ve...İnsan...arasındaki....uyum....ve...düzeyi....korunmalı,...geliştirilebilmeli
..ve....ona...göre....davranış....sergilenmeli.....
.....
.....

4.5.“Let’s Draw Our Environmental Emotions” Activity

In this activity, individuals were asked to depict environmental emotions and interpret the environmental elements in their drawings by associating them with connectedness with nature, biospheric concern, and commitment to the natural environment dimensions. Thus, the following instruction is provided on the form: “Draw your environmental emotions below. Reflect 1. Connectedness with nature, 2. Biospheric concern, and 3. Commitment to the natural environment dimensions. Discuss each dimension on the back of the paper." The participants discuss their drawings and views to reveal similarities and differences between their drawings.

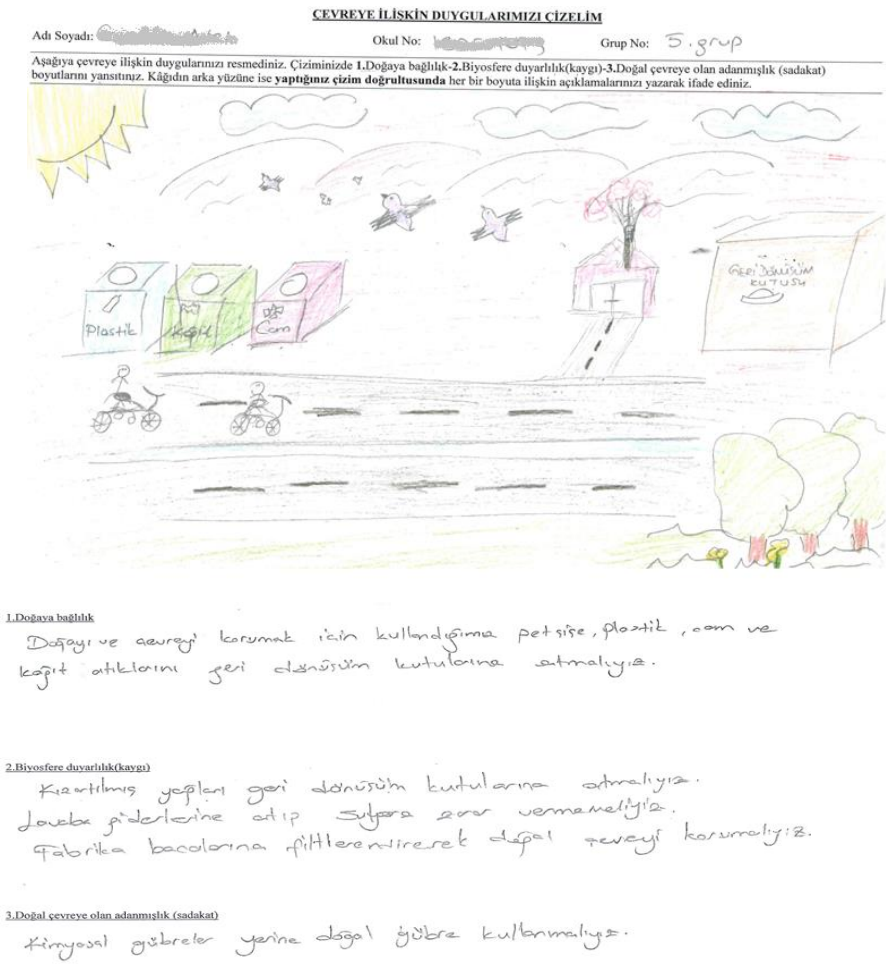


Figure 7: Sample “Let’s Draw Our Environmental Emotions” Activity Form

5. Conclusion

In previous studies on environmental education, it was observed that the authors focused on environmental literacy, which includes several subdimensions (Murphy & Olson, 2008). It could be suggested that these studies mainly focused on the affective domain, which includes attitudes, perceptions, and beliefs (Altuntaş & Turan, 2016). However, there is evidence that environmental perceptions are strongly influenced by affective skills (Kals et al., 1999). Thus, it was suggested that the activities introduced in the present study should be supported by the improvement of affective skills. Since the applications required in this process were based on the conceptual framework suggested in the literature, the present study findings would assist future implementations. Thus, the applications were based on the structural correlations proposed by Schultz (2002) and Carmi et al. (2015).

Environmental emotions play a key role in the active acquisition of environmental literacy and positive attitudes towards environmental problems for a more sustainable environment. Pioneering and responsible environmental behavior has a significant impact on daily life experiences and decisions (Bissing-Olson, 2016). The environmental emotion-enhanced activities were designed with this approach in the current study. Since environmental knowledge is instructed at all formal/informal educational levels and starts from the early childhood in the family, it could be suggested that the employment of these activities would be important for individuals who play a role in environmental education. Previous studies evidenced that the level of environmental literacy improves through various applications. In the present study, various environmental emotion-enhanced activities were employed to develop the affective domain in environmental education.

In the "***Let's Draw a Social Atom***" activity, the individuals were made aware of the people, situations and institutions that affected their environmental emotions. The activity mainly aimed to enabled the individuals to start thinking about their immediate environment towards the more distant layers; and thus, allowing them to think near and far about nature. The activity aimed to encourage individuals to be included with nature rather than being excluded from nature based on the conceptualization of inclusion with nature proposed by Schultz [41]. The "***My Real Feelings About The Environment***" activity aimed the individuals to develop intense feelings about environmental destruction with a video where the consequances of environmental problems were displayed and these emotional experiences were reflected in their views after the application. In the "***Situation-Problem & Emotion-Solution***" activity, participants were asked to focus on environmental situations-problems in daily life that directly affect them. The activity aimed to

determine the environmental emotion component (connectedness with nature, biospheric concern, and commitment to the natural environment) that was associated with the situation-problem and encourage the participants to write a solution. Thus, it was expected that more general environmental problems would be discussed based on individuals' daily experiences. Furthermore, they were expected to think about and offer solutions for issues such as common habitats, ecosystems, forests, as well as genetic deterioration due to radioactive pollution, and factors with detrimental effects on sustainable environment, etc. In the "***Let's Draw Our Environmental Emotion***" activity, individuals were asked to draw their environmental emotions. Then, they were asked to interpret the environmental elements in their drawings by associating them with connectedness with nature, biospheric concern, and commitment to the natural environment dimensions. In the last stage, they were expected to present and discuss these associations in class. The activity aimed the individuals to question to what extent they were connected with nature based on the environmental emotion components. In the "***Environmental Emotion Scenarios***" activity, individuals were asked to reflect the dimensions of connectedness, concern and commitment that constitute the environmental emotion. The activity allowed the participants to reflect their and others' emotions with an empathetic approach. It could be suggested that individual emotions about the environmental issues could help the individuals to connect with global environmental problems associated with their daily lives, based on these scenarios.

It could be suggested that the activities enhanced with connectedness with nature, biospheric concern, and commitment to the natural environment would provide new ideas for future studies in the field and contribute to the development of new approaches in the literature. The environmental emotion-enhanced activities would raise the awareness of individuals about their processes and views, and contribute to the emergence and development of environmental emotions, as well as encouraging them to make and implement environmental decisions in their daily lives. Experimental findings about the activities introduced in the present study were not addressed in this article. Future studies on the implementation of environmental emotion-enhanced activities would not only contribute to active environmental literacy, but report significant psychosociological and eco-pedagogical data on environmental emotion and subdimensions based on the data that would be collected during the activities with the activity forms.

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CHAPTER 6

MOBILE LEARNING IN SCIENCE EDUCATION

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1. Introduction

The world we belong to may be experiencing the fastest development in history these days. Each new day we start welcomes us with new information, more than the previous one or perhaps which claims the opposite of yesterdays. In order to keep up with this development, 21st century individuals need to acquire some special skills. One of these skills, "Information, Media and Technology Skills", is the ability to use technology, as the name suggests. In line with this understanding, some technological tools have made a rapid entry into the educational environment. These tools, called 'Mobile Learning Tools', are special technological tools that facilitate education and training and have some unique features. In this section, mobile learning and mobile learning tools will be examined in terms of some important features they have.

2. Mobile Learning

The concept of e-learning (electronic learning), which emerged with the recent advances on the internet, was described as the integration of education and technologies (Siemens, 2002). Based on the related tools and media where these tools are utilized, the Internet, which became significant in our lives, is among the most important tools that affected education especially due to the popularity of personal computers. The concept of "e-learning", which was introduced due to the developments in the internet and computers, became a significant learning-instruction environment in the education system (Korucu & Biçer, 2019).

Mobile devices integrated with the learning environment led to the introduction of the "Mobile Learning" concept (Woodill, 2011). Mobile learning is considered an important e-learning component that develops with technological advances (Kinshuk, 2003). Certain studies coined mobile learning as m-learning (Alagöz, 2020; Bozkurt 2015; Korucu-Biçer, 2019; Quinn, 2000; Aydoğdu, 2019; O'Malley et al., 2003; Shepherd, 2001), which was the abbreviation of “mobile e-learning” (Mehdipour & Zerehkafi, 2013).

Mobile learning was described as the learning process conducted on mobile devices through social or content interaction independent of time or place (Ozan, 2013). Thus, the need for accessible practical tools such as

mobile devices increases every day (Elçiçek & Bahçeci, 2017). Furthermore, the independence of learning activities of time and place leads to freedom in learning.

Technologies affect almost every aspect of life and became an indispensable tool in education. Innovations and developments in mobile technologies introduced new methods in several industries such as finance, entertainment, education and health. Mobile technologies that include tools that could be transported easily to any environment immediately became an indispensable part of daily lives as they offer several facilities. The integration of these technologies and education led to the birth of "mobile learning" (Altuntaş, 2017).

Alagöz (2020) described the concept of mobile learning as the rapid technological advances and the development of new generation mobile devices due to these advances. These developments led to a new educational model that allows individuals to access knowledge and required educational tools independent of place and time. Similarly, O'Malley et al. (2003) emphasized the diminishing conventional approach to learning activity spaces and described mobile learning as a system that provides continuous facilities that could be employed with mobile technologies without any limits. Keskin (2010) also described mobile learning as learning activities conducted on electronic devices independent of place or time. Thus, mobile learning could also help the students who require responses when they study or fall behind in learning. Mobile learning was escribed as learning with mobile devices that allow access to educational resources, the benefits of provided services and communication with other users, and that improve productivity and efficacy due to instant feedback to user requests (Özdamar Keskin, Kılınç; 2015).

Quinn (2000) defined mobile learning as a learning system that facilitates access to data sources independent of environmental and time constraints, offers improved interaction facilities, supports activity and efficacy in learning, and focuses on the development of individual performance. In another detailed definition, mobile learning was described as a learning model that allows individuals to connect to other mobile devices or users independent of time and place to conduct individual learning activities (Keskin & Metcalf, 2011).

Similarly, Ozan (2013) described mobile learning as learning that occurs via social interaction on mobile devices or content interaction independent of time and place. Thus, it was suggested that the significance of the required mobile tools increases every day (Elçiçek-Bahçeeci 2017).

U-learning (Ubiquitous learning) means learning anywhere, and is a mixture of e-learning and m-learning and allows learning to take place

independent of time and place (Casey, 2008). According to Bozkurt (2015), u-learning, an extension of m-learning, means learning independent of space, time and device, and accessible learning.

According to Altuntaş (2017), mobile learning is a new generation learning approach that combines the real and virtual media and allows individuals to starti and end the learning process whenever they desire. It is independent of a predetermined time and place, it could even be conducted while on the move, and allows individuals to learn and meet their immediate knowledge requirements.

Mobile learning is possible with traditional methods and could be employed in lifelong and distance learning. In lifelong learning model, individuals are responsible from learning (Aydoğdu, 2019). In other words, it was suggested that mobile learning is not only education and introduction on electronic devices but also entails mobility in learning activities. (Shepherd, 2001).

Mobile learning refers to learning on mobile devices such as notebooks, tablet computers, handheld computers and mobile phones (Yuen & Wang, 2004). According to O'Malley et al. (2005), mobile learning is learning conducted on devices such as laptops, tablets and mobile phones, and information processing and storage tools that do not require cables. Korucu-Bicer (2019), on the other hand, listed the devices that could be used in mobile learning as laptop computers, netbooks, tablet computers, pocket computers, wearable computers, mobile phones, smartphones, iPad, iPod touch, digital assistants, portable game devices, personal portable mp3 players, handheld devices, and USB sticks.

Mobile vehicles provide several educational opportunities since they are portable, allow social interaction, exchange of data, face-to-face collaboration, collection of real and simulated data based on the media, place and time, connections with other mobile devices or networks, and individualization (Klopfer, Squire, Holland, & Jenkins, 2002). These unique features necessitate the employment of mobile devices in learning environments. Due to the fact that distance education is preferred in learning processes due to technological advances, mobile learning became a significant option for distance education, where individuals could participate in educational environments with portable devices (Gülseçen, 2010).

In the 21st century, described as the "technological age" or "digital age," individuals should acquire creative and critical thinking, imaginative, design, active technology use, and mobile learning skills (Yıldırım, 2018).

The introduction of mobile learning technologies led to facilitated access to educational facilities from anywhere. This led to the revision of

the curricula by the educators. Thus, an opportunity emerged for the development of a new educational field (Burden & Kearney, 2016).

Mobile learning has spread due to the integration of students' learning responsibilities and mobile technologies, individualization of learning, and learning by doing and living opportunities (Özdamar Keskin, 2011). Thus, teachers could communicate with their students on online classes, which was quite different from the classical classroom environment. In online classes, teachers could share all types of data such as assignments with their students. Thus, mobile learning also reinforces student learning during instruction (Frohberg et al., 2009).

Berberoğlu (2020) argued that due to the popularity of digital devices, mobile learning turned into a requirement or an obligation rather than a preference, and mobile technology tools - tablets or mobile phones - became an everyday tool in the hands of almost all students. Berberoğlu stated that mobile devices are always in our hands, but we cannot carry textbooks everywhere. Thus, it is possible that mobile applications would replace textbooks in the near future.

According to Büyükkalkan (2020), mobile learning allows the students to access instructional content tailored to their needs, and teachers to change educational activities based on these emerging needs, leading to significant opportunities. Thus, it could be suggested that mobile devices add flexibility to instruction.

3. Mobile Learning Tools

The mobile learning tools may vary based on the time of employment. These tools were reported as mobile phones (smartphones), PDAs (pocket computers), laptops, tablet computers (Oran and Karadeniz, 2007; Kantaroğlu, 2017; Şahin, 2017), interactive whiteboards, student response systems, video conference systems, kiosks (Şahin , 2017), game consoles (Şahin, 2017; Kantaroğlu, 2017), servers (Oran and Karadeniz, 2007), e-books (Anameriç & Rukancı, 2003), wearable computers, smart watches, virtual reality glasses, ultra-mobile computers and portable media players (Kantaroğlu, 2017).

3.1. Mobile Phones

Among mobile devices, smartphones are the most common devices employed in mobile learning (Kantaroğlu, 2017). In addition to the telephony features such as messages, voice and video calls, they also function as a computer since they can connect to the servers, access electronic mailboxes, and run office programs. Due to technological advances, keyboards on mobile phones were converted into touch screens and the screens became larger over time.

3.2. Laptop Computers

Portable computers that include more comprehensive features have replaced the desktop computers. Laptop computers could establish wired and wireless internet connections and devices such as external hard disks, USB sticks, mouse, and speaker could be connected to laptop computers. The battery life and weight of these devices that could provide more comprehensive mobile learning, make them difficult to use (Oran and Karadeniz, 2007).

3.3. Tablet Computers

Tablet computers are lighter and more portable than laptop computers and have larger screens than smartphones, and quite practical (Aydoğdu, 2019). Internet access and external storage capability when needed allow the users to carry data. These devices are usually touch screen and could be operated with fingers or optional pens.

3.4. PDAs (Pocket Digital Assistants)

PDAs (Personal Digital Assistants), which are mobile phone-size handheld computers (Aydoğdu, 2019), were popular before the mobile phones (Şahin, 2019). These pocket-size small computers could match the quality and the functions of the current computers. PDAs generally use IOS, Android, Windows CE and PalmOS operating systems. The PDAs offer touch screens that could be operated with special pens or fingers. They offer memory card slots and wireless connectivity for data storage. PDAs could have many features such as mobile phone lines, GPS, camera, calendar, calculator, notepad, virtual keyboard for text entry, and contacts. They are employed in education, medicine and automobile industries for inventory control and customer tracking.

3.5. Wearable Devices

Technological advances led to the employment of wearable computer systems and augmented reality applications. Thus, mobile applications, smart glasses, holograms, bionic contact lenses, virtual retina viewers are manufactured and used for different purposes in different fields such as education, health industry, manufaturing and airports (İbili & Önal, 2017).

Wearable computers are devices that are placed on a part of the body, in other words, they are worn. Wearable computing technology employs the interaction between a human and the computer, wireless and portable technologies. It often provides hands-free use. There are several wearable computing devices based on intended use. They could be head-mounted displays, ring scanners, smart clothing, wearable computers, smart watches, glasses, wristbands or jewelry.

3.6. Virtual Reality Glasses

Virtual reality glasses are technological tools designed for the more realistic perception of images produced by several devices such as televisions, computers and phones via visual illusions These glasses, which became quite popular in recent years, offer a 360-degree view. The applications installed on smart phones allow certain activities such as watching 3D movies and playing virtual reality games with these glasses.

3.7. Portable Media Players

Portable media players are mobile devices that could play and store images, audio files, videos and other digital media (Kantaroğlu, 2017). These tools are often used with flash drives, micro disks, hard disks, CD, DVD, and Blu-ray players. However, due to the popularity of tablet computers and smartphones, they are no longer popular.

3.8. Video Conference Systems

Video conferencing system is a communication technology that allows simultaneous communication between two or more individuals at different places. Furthermore, video conferencing systems are used in educational activities such as conferences, meetings, medical conferences, and distance education. Internet connection, a microphone and a camera are required for face-to-face communication in video conferencing.

3.9. Interactive Boards

Interactive (Smart) Board is simply a system that allows computer programs to run on the board. Thanks to the project that entailed the implementation of smart boards in schools in recent years, integration of technology in the educational environment was accomplished and the classes became more effective and efficient. Interactive boards, which could easily display various graphics, operations, drawings, pictures, shapes, topical videos, were designed for ease of use by the students. They provide touch screens. Since the space on interactive boards is unlimited, no content is deleted, the pages can be opened and saved multiple times. They also save time in content transfer in classes.

3.10. Student Response Systems

These devices, also known as audience response systems, allow the students respond to questions asked by the teachers spontaneously in educational environments. Thus, each student's response is monitored for fast feedback. The systems make the classes fun and allow students to be active in a high-interaction classroom.

3.11. Kiosks

The kiosk devices, which could be observed in various applications, are primarily used in banks or hospitals as ticket dispensers. However, they are also used by several institutions for invoicing and debt payment, ticket or coin purchases, direct product purchase, documentation and receipts, sales, marketing, promotion and advertising. In education, the kiosks are used in cafeterias and libraries for fast and easy transactions. The biggest advantage of kiosks is to save time by decreasing staff workload in the institutions.

4. Advantages of Mobile Learning

Previous studies reported that mobile learning had several advantages. Bulun et al. (2004) summarized these advantages as follows:

Lifelong learning: Today, information is dense and changes rapidly. This made "Lifelong Learning" even more important. While too much information is difficult to record in the human mind, and even though it is recorded in the mind, the rapid and continuous changes also change the required knowledge frequently. Thus, it is necessary to provide individuals new knowledge with the easiest method and fast and practical devices that are flexible enough to keep up with these changes.

Learning when needed: When the individual accesses the required information, learning is permanent. Learning when needed is effective. The most adequate tool for learning when needed is technological devices. The individual could easily achieve this with mobile devices.

Unintentional learning: Continuous instruction efforts overwhelm the learners. As a solution, the concept of "Unintentional Learning" was introduced. The method conveys the desired messages to the individual as if they were a natural part of life, leading to lifelong learning in an environment where the individual is not overwhelmed by rules of formal learning environments.

Time and space independent learning: It is quite difficult to argue that the distance education conducted on the internet and computers recently is time and place independent. Because it is not possible to carry the computers everywhere and the internet connected via a cable restricts movement. Thus, time and place independent learning is only possible on mobile devices and with wireless internet technologies.

Learning tailored to the location and conditions: The information we need at a particular time or in a particular season may differ. Or our location may lead to different information requirements. Thus, the required information could be easily accessed via mobile devices.

Stating that mobile devices are employed all over the world, Ozan (2013) listed the advantages of mobile learning as follows:

- ✓ Improvement of the equality of opportunity,
- ✓ Facilitating the learning processes of individuals with disabilities,
- ✓ Facilitating individualized learning,
- ✓ Spontaneous feedback and evaluation,
- ✓ Development of new learning groups,
- ✓ Improvement of communication and management processes,
- ✓ Support of circumstantial learning,
- ✓ Bridging formal and informal learning,
- ✓ Active utilization of classroom hours,
- ✓ Improvement of cost-efficiency.

Attewell (2005), who considered mobile learning unique in providing individualized learning at antime, anywhere and suggested the feasibility of mobile learning to improve the courses, end boredom or make a difference in the process, reported that mobile learning could have the following benefits:

- ✓ Mobile learning helps students acquire literacy and numeracy skills and realize their existing competencies,
- ✓ Mobile learning could contribute to both collaborative learning and independent studies,
- ✓ Mobile learning helps students identify the areas where they need assistance,
- ✓ Mobile learning helps remove unnecessary learning processes and improve the interest of reluctant students in the course,
- ✓ Mobile learning extends student focus on the course,
- ✓ Mobile learning helps improve student self-esteem and self-confidence.

5. Limitations of Mobile Learning

Similar to all methods, mobile learning has certain limitations as well as advantages. Shudong and Higgins (2006) categorized these limitations as technological, pedagogical, psychological and other limitations:

Technological limitations: processor speed, memory capacity, battery life, screen size, screen resolution, operating system, software and internet browsers.

Pedagogical limitations include the employment of mobile devices for other purposes such as social media, non-educational games, listening to music, and messaging by the students. Furthermore, the inability to measure the process properly in the evaluation phase could be an example for pedagogical limitations.

Psychological limitations include students' inability to give up their old habits and conducting the learning process with old and accustomed methods that are easier for them. Because the complex structure of mobile devices is a factor that makes them difficult for students to learn all features.

Other limitations include the investigation of how mobile devices are used and the benefits they provide, data security and privacy, and detailed analysis of the learning process both from an institutional and socio-cultural perspective.

Furthermore,

- ✓ Distraction of adolescents due to frequent social media use (Berberoğlu, 2020),
- ✓ Solitude and isolation of individuals due to extended smartphone use, leading to depressive tendencies and reduced tolerance (Yıldırım, 2018),
- ✓ The numerous alternatives of mobile learning applications, high number of learning application developers, resulting efforts by the users to select an application (Altuntaş, 2017),
- ✓ Increased risk of technology dependency due to spending too much time on mobile devices by high school, middle school, even primary school students who are in cognitive and physical development stage (Berberoğlu, 2020),
- ✓ Frequent internet connection problems,
- ✓ Small keyboard (Gülseçen, 2010),
- ✓ Lower back and neck pains due to long-term and inaccurate use of mobile devices (Yıldırım, 2018),
- ✓ Negative effects on eyesight.

6. Global Mobile Learning Developments Mobile Learning in the World

Countries in the Asia Pacific Region are increasingly seeking information and communication technology capabilities to expand educational services and accelerate financial development. Mobile phones and IT applications are also increasingly considered as an important tool in these countries for access to world-class instructional material and to improve the quality of education (Lee & Hassan, 2018). Several studies reported that information and communication technologies have a significant impact on learning and teaching styles (Eristi, Haseski, Uluuysal & Karakoyun, 2011; Martin, Diaz, Sancristobal, Gil, Castro & Peire, 2011; Suki & Suki, 2011).

Ogunmakin (2018) also reported that information and communication technologies are currently considered as a facilitator of

development in most countries, and productivity gains in developed world economies were attributed to the impact of information and communication technologies. Ogunmakin added that although several countries strive to adopt information and communication technologies in instruction, there was insufficient evidence to demonstrate the success of this in developing countries such as Kenya.

In early 2000s, Crabtree (2003) emphasized that mobile learning theory should be aware of the individual and collective employment of technologies and 75% of the society and 90% of young adults in the UK owned handheld devices. Yau, Leung, and Chung (2018), on the other hand, reported that almost every student owned a mobile device, mobile learning became more important due to rapid technological advances, and if this continues, mobile devices would replace conventional learning, textbooks, hand-written notes, etc. Similarly, Herrington and Herrington (2007) described mobile learning as a process facilitated by mobile devices. Hahn (2008) supported this view by stating that for our highly planned, commodified, oppressed students, we need information - organized and accessible information - anytime, anywhere.

Mobile learning, developed as an extension of e-learning, has been employed in several public and private organizations, museums and educational institutions around the world. Providing examples for several mobile learning applications in the world and in Turkey, Sayın (2010) indicated the The Learning Springs (TLS) high school, which was established in 1993 in the United States of America. The exclusively distance education high school provides an internet-based multimedia program for students who travel continuously for familial reasons, cannot attend school for various reasons or learn slow due to learning style differences, and thus unsuccessful in several courses. The school offers more than a hundred courses on the internet, and successful students get a high school diploma.

One of the reasons for the prevalent use of mobile devices worldwide is their video playback and recording features. Thus, mobile phones that can record video are preferred instead of carrying a video recorder and a phone at the same time. People can share videos with others over wireless networks via mobile devices. Thus, mobile devices allow the employment and communication of educational videos (Sayın, 2010). Similarly, Traxler (2005) emphasized that mobile learning is possible and supported by mobile phones. On the other hand, Douch et al. (2010) reported that mobile technologies could contribute to teacher training and professional development in innovation, self-evaluation and communication skills. They indicated that mobile technologies could assist the development of novel ideas and creative thinking, allow to record the

lectures for reuse in future instruction, and facilitate communication through video calling services such as Skype.

Zydney and Warner (2016) reported that certain studies in the literature focused on specific aspects of mobile learning such as mobile applications (Jeng, Wu, Huang, Tan & Yang, 2010), mobile learning games (Avouris & Yiannoutsou, 2012; Schmitz, Klemke & Specht, 2012) or mobile computer-assisted cooperative learning (Hsu & Ching, 2013). Furthermore, other studies investigated mobile learning trends (Hung & Zhang, 2012; Hwang & Wu, 2014), the impact of augmented reality-based mobile learning systems on student achievement and motivation (Chiang, Yang & Hwang, 2014), the contribution of mobile learning to individual knowledge management (Liaw, Hatala & Huang, 2010), an interactive conceptual map to support mobile computer-assisted collaborative learning (Hsu & Ching, 2013), mobile learning activities (Hwang, Wu & Ke, 2011) and the development of an interactive mobile learning environment (Tan, Liu & Chang, 2007).

Conferences have been conducted on mobile learning in various countries. Traxler (2005) reported that a workshop was organized on mobile learning in computer classes in Telford in 2002, the Social Science Conference on Mobile Learning was organized in Budapest in 2002, International Communities and Technologies Conference was organized in Amsterdam in 2003 and in Wolverhampton in 2004, Handheld Computer Training Workshop in Universities and Colleges was organized in Telford in 2005.

7. Mobile Learning in Turkey

Turkey has certain opportunities in learning since mobile device ownership and internet access with these devices increase every day (Alsancak-Sırakaya & Seferoğlu, 2018). Telli Yamamoto & Altun (2020) reported that while the population increased by an average of 1.4% every year in Turkey, internet access increased by 9.3%, and the increase in internet use should not be explained by the increase in younger population but also with the increase in internet use among middle aged and elderly population. The internet use is prevalent more than ever, especially due to the distance education applications adopted due to the COVID-19 pandemic. Thus, mobile learning has been commonly used in distance education in the world and in Turkey during the pandemic. However, despite these developments, it was reported that mobile learning is not instructed in higher education institutions, and distance education programs in certain universities were integrated with the programs in other universities (Alsancak-Sırakaya & Seferoğlu, 2018). Furthermore, it was reported that there are almost no mobile application developers in Turkey, and existing specialists either work in large-budget mobile projects abroad

or for an hourly fee determined by private GSM companies (Özdamar-Keskin & Kılınç, 2015).

Certain studies indicated that the number of studies on mobile learning was limited in Turkey (Çakır, 2011; Kuşkonmaz, 2011), and other studies reported that the above-mentiıned number increased especially by 2010 (Korucu & Biçer, 2019; Solmaz & Gökçearslan, 2016). In the meta-analysis conducted by Solmaz and Gökçearslan (2016) on postgraduate theses on m-learning submitted between 2005 and 2015, it was determined that the number of studies increased after 2010. It was reported that most studies were master's theses. In a study by Korucu and Bicer (2019), it was reported that the number of studies on mobile learning increased in recent years and the increase could be due to the increase in mobile technology use and the recognition of the advantages of mobile technologies in learning.

Erdem, Kalkın, Türen, and Deniz (2016) reported that more than half of the students feared of mobile phone deprivation (nomophobia) and they spent around 6.5 hours a day on smartphone. Furthermore, it was concluded that there was a positive correlation between nomophobia levels among these students and their daily smartphone use and a negative correlation between nomophobia and academic achievement. Thus, students spend more time with their mobile phones due to the fear of mobile phone deprivation. Since the fear of mobile phone deprivation is among the mobile phone dependency indicators (Erdem, Türen & Kalkın, 2017), it could be suggested that there is a negative correlation between student achievement and mobile phone dependency. In other words, the longer the mobile phone use, the less student achievement. Similarly, several studies (Smart & Gezgin, 2016; Bülbül & Tunç, 2018) reported that student achievement decreased with an increase in mobile phone use.

Thus, it could be suggested that mobile learning has been an inevitable learning approach due to its advantages in the current period; however, similar to every learning approach, there are certain issues that should be considered during the employment of this approach. These issues include the time spent in front of the screen physical, mental and psychological (dependency, asocial behavior, etc.) problems that could be experienced when excessive time is spent on these devices and decrease in the duration and quality of real (non-virtual) social relationships. Thus, similar to every educational application, distance education program developers, educational institutions, teachers and parents have important responsibilities.

Alsancak Sırakaya and Seferoğlu (2018) summarized their views on the advantages and disadvantages of the mobile learning based on the

literature review they conducted on mobile learning in Turkey is presented below:

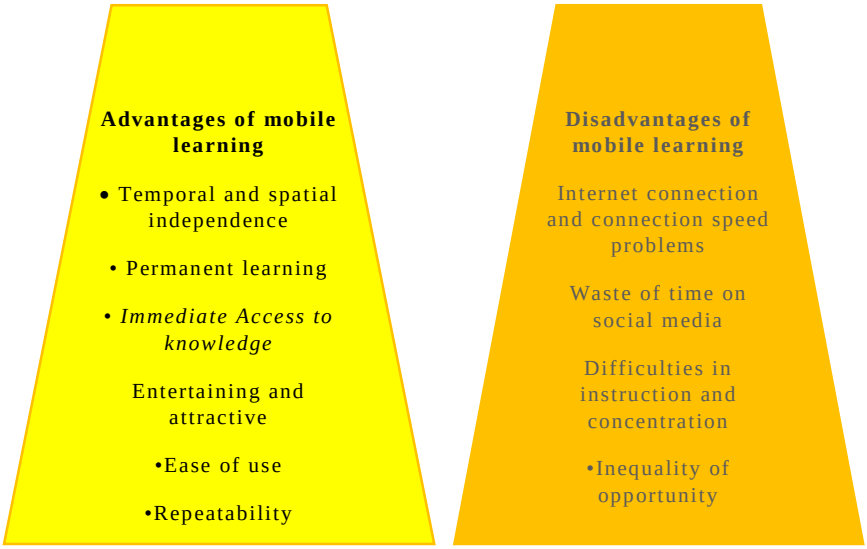

Figure 1: Advantages and disadvantages of mobile learning (Alsancak Sırakaya & Seferoğlu, 2018)

8. Mobile Learning in Sciences

In the 21st century, several nations aimed to adopt and actively utilize certain technologies to improve competitiveness and development levels. Due to these goals, the competition in the technological fields has significantly increased and serious progress was observed in fields such as industry, transportation, education and communication. Science and technology strategies were planned based on these goals in Turkey, similar to the rest of the world. Digital education and instruction content has been among these strategies (Alagöz, 2020). Digital content in the 2023 Educational Vision published by the Ministry of National Education (2018) was stated to include tools with a strong educational approach, topical integrity that value conceptual depth and high interaction. This real world content includes games that require the association of multiple disciplines and significant projects, animations that include abstract concepts, difficult to perform interactive experiments and simulations, and new generation measurement tools where all the above-mentioned activities are employed in evaluation. The employment of digital content in education aims to provide student access to knowledge and skills as needed and increase their interest and motivation in learning. Access to knowledge when needed would also ensure the permanence of knowledge.

To train mentally superior, practical and qualified manpower to meet the daily life requirements became the objective in science curricula in

educational institutions. Science plays a key role in the development of national welfare and peace, social, cultural and economic progress and development of national unity and solidarity, the steps towards a productive and skilled nation, and the achievement of contemporary civilization (Yıldırım, 2020).

The objectives of science curricula are similar to the 21st century skills. "Life skills", one of the field-specific skills in the curriculum, are the skills that individuals should acquire to overcome the difficulties they encounter in daily life and to produce solutions for these problems. Thus, the significance of science education has increased in several countries, due to its contribution to training individuals for the requirements of the new century.

Natural sciences, by their very nature, are associated with daily life. In other words, science is life itself. However, similar to several countries, scientific achievements are not at a desired level in Turkey. The factors that lead to learning difficulties in the science course include mathematical expressions, inability of the students to interpret graphics, calculation requirements, and abstract concepts (Timur & Özdemir, 2018). The integration of educational mobile applications into the instruction could help overcome the above-mentioned difficulties (Genç, Albayrak, Söğüt; 2019). Because mobile devices improve student interest in the class, ensure participation and make the class more entertaining.

Çepni (2005) reported that computer software that are among mobile learning tools have the following advantages in science courses:

- ✓ Materialization of abstract concepts: It may be difficult for students to imagine abstract concepts due to their age. Thus, materialization of these concepts could clarify them in the minds of the students.
- ✓ It helps them to analyze life events by accelerating the events that may occur in a long time or by slowing down the events that may normally occur very quickly in life. Furthermore, it allows the students to learn at their own pace.
- ✓ By improving the comprehensibility of the concepts before conducting real experiments and eliminating possible misconceptions, it could improve student learning during and after the experiments.
- ✓ It could be used to conduct precise measurements and record data during laboratory experiments.
- ✓ It could allow to conduct the experiments that require too much time in real tool or could not be conducted due to the lack of test tools and equipment, safety and cost factors. Thus, almost all

activities could be conducted in the science course since these devices remove most limitations.

9. Conclusion

As mentioned in the section, mobile learning has many advantages that are especially relevant today. However, perhaps the most striking of these advantages is the independence of time and space. Because this independence makes learning very effective in terms of the individual's ability to freely perform learning whenever and however he/she wants, without restrictions. For example, in previous years, the books acquired by individuals were, in their most up-to-date form, books published at the beginning of the semester. However, today, thanks to mobile devices, every information and even the partially or completely changed version of this information can be accessed on a daily basis.

With the effect of developing technology, mobile learning also has an important place in terms of adapting individuals to the 21st century. This importance also draws attention in the field of science. Because science, by its nature, has a dynamic structure that is constantly changing and developing. For this reason, individuals have to access information themselves at any time. Individuals will have to be intertwined with mobile learning in their future lives. Therefore, every individual should internalize mobile learning, have the knowledge, experience and infrastructure required by mobile learning tools and be ready to use these tools.

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CHAPTER 7

LEARNING AND TEACHING IN 21ST CENTURY

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1. Introduction

This chapter addresses the learning and teaching processes in the 21st century. The topic is discussed in four sections: Being a Student in the 21st Century, Being a Teacher in the 21st Century, Learning in the 21st Century, and Teaching in the 21st Century. Thus, to describe the individual traits of the century and the differences between the traits of the individuals in previous periods and the current century, the generational identification of individuals in the society and their experiences were also included in the discussion. Student and teacher attributes were introduced, and certain concepts (digital natives, digital migrants) and educational technology tools employed in the learning and teaching process (Web 2 tools) were also discussed.

2. 21st century skills

Individuals' learning needs are important individual, social and global requirement. This requirement has existed since the existence of human beings. Because various changes and transformations have been observed in all ages. These changes have led individuals, the society, and the world to various requirements. This cycle has continued for years.

Similar to every century before it, the 21st century has witnessed unique changes, developments and requirements as a result of these changes. In general, this century has started with the rapid advances in science and technology and the impact of these advances on individuals' living, working and learning approaches has been different. Due to the advances in information and communication technologies, society has been transformed from an industrial society to an information society (Voogt, 2008). The 21st century requirements could be explained with the concepts of entrepreneurship, technology integration and innovation.

The 21st century skills that allow individuals to meet current requirements and to live productive lives could mainly be acquired in education (Belet Boyacı & Güner Özer, 2019). It was reported that the current changes also affected education systems and the knowledge and skills that individuals need to acquire should be changed accordingly (Cansoy, 2018).

The 21st century skills were described as the high-level skills required for new generations to succeed in the global order (Altun &

Arslan, 2021). In the 21st century, success in life was associated with reflection, creativity, daily problem-solving, critical thinking, entrepreneurship, technological, productivity, and marketing skills (Benek, 2019: 58). The 21st century skills have been described with several definitions by many individuals and organizations. According to Ekici, Abide, Canbolat, and Öztürk (2017), although there is no consensus on the definition of these resources, there is a consensus that the skills mentioned in these definitions are the 21st century skills.

Voogt, Erstad, Dede, and Mishra (2013) reported that digital literacy was significant as one of the core 21st century competencies. They described it as a broad set of core media skills that are partially consistent with other 21st century competencies. These include competencies such as gaming, distributed cognition, performance, multitasking, etc. In other words, they suggested that digital literacy has various aspects and often evaluates the other 21st century competencies from a different perspective.

Education is affected by the social conditions, requirements and expectations of the current century. The 21st century education approach focuses on the acquisition of skills rather than knowledge by revealing individual's skills and capacity. Instead of the standard tests common in the traditional educational approach, the achievements are measured by projects, problem solving, creativity, innovation, certificates and number of patents (Uçak & Erdem, 2020).

"Coding skill", a 21st century skill, is consider a part of logical reasoning skills (Sayın & Seferoğlu, 2016). Coding skill education is conducted in "coding education and programming" courses. Coding education is included in the curricula in various countries with different names. It is called "algorithmic problem solving and programming" in Bulgaria, "computational thinking and programming" in Belgium, "programming, algorithm and robotics" in Spain, "programming" in Estonia, Ireland, the UK, and France. Finland and Poland preferred the more common term "programming" to coding (Balanskat & Engelhardt, 2014).

Individuals should determine self-learning and collaborate with other individuals, groups or technological devices in the 21st century (McCoog, 2008). The technology could be used to work both individually and in groups. Especially the employment of computers and the internet fulfills the requirements of the century for the students rapidly.

Abao, Dayagbil and Boholano (2015) reported that the 21st century emphasized globalization and internationalization, and each technological advance offers theoretical structures and realistic insight for the development and improvement of knowledge, skills and attitudes among students and teachers. In other words, technological advances have

contributed to student-teacher interaction due to the availability of theoretical and internal real knowledge in the learning-teaching process.

Since the 1900s, there have been generations with various common traits. The term "Lost Generation" has been used for the generations who were born before 1900. The individuals who were born between 1883 and 1900 and reached adulthood in this period were known by this name due to the World War I, which led to significant loss of human life. In the war, heavy weapons developed with then current technology were employed, especially chemical weapons were used for the first time in history. With more than 16 million casualties, the war had a devastating global impact. It is known that those who managed to survive after the war felt aimless and psychologically lost.

The people born between 1900 and 1924 are known as the "Greatest Generation" (GI). The term stemmed from the fact that the generation included the soldiers who fought in the Second World War. The term "Interbellum Generation" used to describe the Americans between the Lost Generation and the GI Generation, born between 1901 and 1913 and between the World War I and II. The name was selected to reflect the fact that this generation was too young to serve in the army during the World War I and too old for conscription in the World War II (en.wikipedia.org).

The individuals born between 1925 and 1945 are called the "Silent Generation". This generation includes individuals who experienced the "Great Depression" in 1929. They lived under and struggled with great economic difficulties. Individuals in this generation experienced the negative effects of the World War II, as their parents did in the World War II. The individuals born between 1946 and 1964 are called "Baby Boomers." In the period, the highest birth rates were observed. The period also corresponds to the period between the World War II and the Cold War.

Between 1965 and today, the generations were called X, Y, Z and Alpha generations with unique characteristics. These generations experienced different living conditions and various learning environments. Generation X includes individuals born between 1965 and 1980, Generation Y includes individuals born between 1981 and 1996, Generation Z includes individuals born between 1997 and 2012 and those who were born after 2012 are called the Alpha generation. Xennial generation refers to individuals born between 1975 and 1985. This generation includes those who were born in the period between the generations X and Y. This generation was introduced in the articles published Good magazine by Oelbaum and Stankorb (2014) for the first time and was described as a micro generation that functioned as a bridge between the dissatisfaction of the generation X and the bright optimism of the generation Y. In other words, the Xennials were as angry as the

generation X. It represents a group that was not as confident as the Generation Y.

With the introduction of the internet in late 1980s, the generations X, Y, Z and especially the Alpha generation had internet access. Increasing accessibility of knowledge, creation of knowledge and new products became common due to the internet and technological advances. Previous generations and related time periods are briefly depicted in the image below:

Figure 1. Generations (MyEnglishTecaher.eu)

The internet, which became prevalent in every field, was also rapidly integrated into the field of education. In the early 1990s, the internet was called Web 1. McCoog (2008), who attributed this to the relatively lonely and static internet at that time, classified the generation Y as the first significant users of the internet, and stated that digital technology was an almost birthright for the generation Z and schools should adapt to the internet: "They use the Internet, which is called Web 2 and is more dynamic and collaborative than the previous generations." Web 2 is a concept that introduced by O'Reilly Media in 2004 and describes the second-generation internet services, which include a system that is created by internet users in collaboration. In other words, the Web 2 is an internet that allows individuals not only to read content but also to create digital content. Web 2 includes sites that users visit for other to reach other users such as YouTube, Wikipedia, Del.icio.us, Flickr, Ekşi Sözlük, Pilli Network, Facebook etc. (tr.wikipedia.org). The employment of these networks in education is also common. In addition to these networks, applications such as Edmodo, ClassDojo, Kahoot, Popplet, WordArt, Scratch, Canva, Coggle, Blogger, Edpuzzle, Google Forms, Forvo, Thinglink, Storyboardthat, Google Jamboard are widely preferred Web 2.0

tools in the field of education. These tools are discussed in the 21st century teaching section.

3. Being A Student in the 21st Century

In every century, there have been certain common skills that should be acquired by the students. However, in addition to the skills required in previous periods, there are certain skills that are considered significant in the 21st century. These are flexible thinking, critical thinking, problem solving, universal citizenship, visionary leadership, innovation, collaborative communication, self-directed learning, digital literacy, financial and economic literacy, information and media literacy, scientific literacy, science and technology literacy, global (holistic) awareness skills. The 21st century student skills have been described with several definitions in the literature (AASL, 2007; Carlgren, 2013; Dicerbo, 2014; Dweck, 2009; Lai & Viering, 2012; Saavedra & Opfer, 2012). The prominent skills based on these definitions include creativity, productivity, critical thinking, information literacy, media literacy, technology literacy, flexibility, leadership, communication, entrepreneurship, social and collaboration skills.

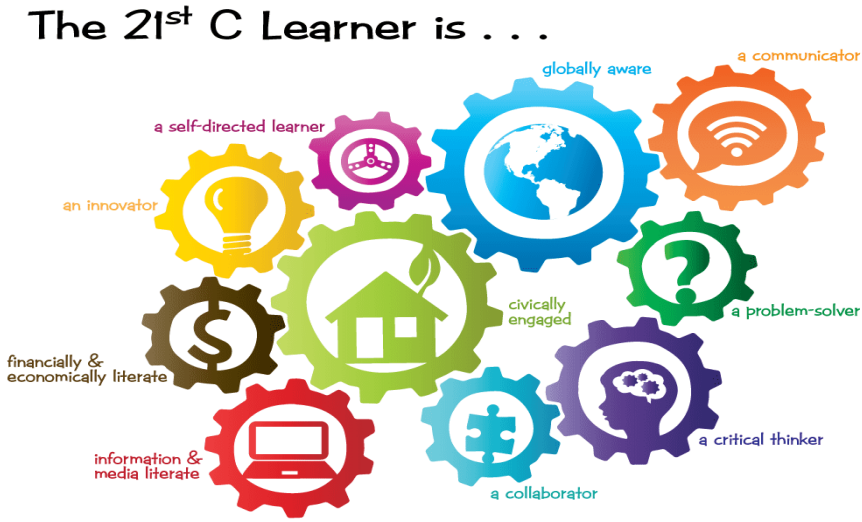

Figure 2. 21st century learner competencies (www.smiletutor.sg)

The 21st century lifelong learner traits and skills are summarized by Collins (2009) and presented in Table 2.

Table 2. Lifelong Learner Traits and Skills

Traits	Skills
Innovative in practice	Self-directed learning skills
Venturesome and creative	Well-developed communication skills
Resourceful	Information-seeking and retrieval skills
Curious	Metacognitive skills (skills for "thinking about thinking")
Motivated to learn	Higher-order thinking skills
Willingness to make and learn from mistakes	Able to work as a change agent
Confident in ability to learn from others, share what they know, and accept feedback	Able to develop and use defensible criteria for evaluating learning
Persistent	Able to share good practices and knowledge
Interdependent and interpersonally competent as well as independent and self-sufficient	
Flexible in thinking	
Responsible and accountable for work	
Logical and analytical	
Methodical and disciplined	
Adaptable to changing healthcare needs	
Reflective and self-aware	

Today's students, who grow up in a fast-paced digital world, could easily go beyond the traditional course-oriented classroom (McCoog, 2008). The first trait that differentiates these students from the previous generations is access to the internet since their birth. Thus, according to Kinash and Crane (2015), several studies demonstrated that 21st century students are more connected and stronger than previous student generations and feel entitled to quality education. According to them, technological advances and changes in higher education and employment market create new learning requirements in addition to the desires of the current students. However, despite the benefits of 21st century such as

unlimited internet access, there are also dangers associated with the century. These dangers include psychological and physical health problems. The are several studies on internet access and protection of children in the literature (Alguliyev & Ojagverdieva, 2019; Byrne & Burton, 2017; Djanggih, Thalib, Baharuddin, Qamar & Ahmar, 2018; OECD, 2011; Tarı Cömert & Kayıran, 2010; Terkan & Taylan, 2010). In Turkey, it was observed that the 21st century student traits were listed as follows in the reports published in "MoNE 21st Century Student Profile Workshop" (MoNE, 2011):

1. Rapid access to information
2. Mobile learning skills,
3. Various (media, information technologies, etc.) skills,
4. Multitasking skills,
5. Self-evaluation skills
6. Group learning skills
7. Self-determination of learning content
8. Inter-disciplinary learning approach
9. Problem-based learning skills
10. Focus on the process and product
11. Basic ethical principles
12. Coexistence in a multicultural environment
13. Tolerance for differences
14. Sensitivity for social problems
15. Knowledge on national culture
16. Problem-solving skills
17. Comprehension and interpretation of the past
18. Reflection about the future
19. Large-scale project development skills or participation in large-scale projects
20. Design skills
21. Holistic approach
22. Recognition of global trends
23. Cooperation and discussion skills
24. Knowledge development, production, and transfer skills
25. Active participatory citizenship awareness
26. Risk evaluation and risk-taking skills
27. Curiosity
28. Reading comprehension skills
29. High interpretation skills
30. High expression skills (self, events, etc.)
31. Language skills
32. Questioning skills

33. Asking the right questions
34. Creative-thinking skills
35. Learning to learn
36. Scientific research skills
37. Awareness about the value of knowledge (and science)
38. High self-esteem
39. Healthy living skills
40. Sports culture and participation in sports activities
41. High artistic and aesthetic taste

It was observed that 21st century student profile was also included in the reports published in the "MoNE 21st Century Student Profile Workshop" (MoNE, 2011):

1. 21st century student is the center of education
2. The student is responsible with learning
3. The student does not wait for others to serve information
4. The student is curious
5. The student is sensitive about the events in the environment
6. The student is social
7. The student is challenging
8. The student is entrepreneurial
9. The student is active and productive
10. The student is industrious and impetuous
11. The student can self-express verbally and in writing
12. The student is technology literate
13. The student acts based on scientific approaches and trusts in experimentation and requires evidence
14. The student is critical and questioning
15. The student is tolerant and respects different views
16. The student is courageous, takes risks and is optimistic
17. The student is creative and innovative
18. The student is a global citizen but devoted to national culture
19. The student is optimistic, courageous and takes risks
20. The student thinks intuitively
21. The student can associate, supervise, scrutinize, and analyze (MoNE, 2011).

The "digital natives" and "digital migrants" are other distinct concepts in this century. These concepts are prevalent in the 21st century and it was suggested that they were not based on solid scientific research (Kirschner & Bruyckere, 2017). The following sections are devoted to this discussion:

3.1. Digital Natives

The term digital native was introduced in 2001 by Marc Prensky, an education consultant. This term has been to describe the generation born

after 1984 (1980 according to others). It was argued that the 8-bit computer games were first introduced in this period and the individuals born in this period were born during the personal computer revolution and they should be called "digital natives" (Şener, 2017). According to Prensky (2001), these individuals are the current young adults (i.e. those born after 1984) who grew up in the digital age. And the exposure of these young individuals to digital technologies provided specific and even unique traits that completely differentiate them from previous generations. It was even assumed that digital natives have digital technical skills and learning preferences that the conventional education does not have the means to accommodate. However, Kirschner and Bruyckere (2017) argued that there was no such difference and being born in the digital age does not entitle these people a privilege that individuals born previously do not have. According to Kirschner and Bruyckere (2017), Prensky coined the term digital native based on the rationality of the phenomena and behaviors he observed, not on extensive research about this generation. Prensky (2001: 1) observed these children surrounded with computers, video cameras, video games, cell phones, digital music players, and all other toys and gadgets of the digital age.

3.2. Digital Migrants

Digital migrants are those who were born before digital natives and did not have any personal computer background, experience or education. They were also described as individuals born before the millennium (internet and web age), who encountered technological products during post-adolescence (Arabacı & Polat, 2013). Also, it was reported that digital immigrants are a generation that was not familiar with digital media tools but tried to adapt to the digital culture (Çetin & Özgiden, 2013). Wang, Myers, and Sundaram (2013) described digital migrants as those who learned to use a computer at some stage during adulthood.

Autry and Berge (2011) stated that until recently, the only research method was to utilize the resources available in the local library. According to them, libraries are now a secondary resource for most individuals in developed countries. The primary resource is now the internet. Thus, the digital migrants were replaced by digital natives in this process.

4. Being a Teacher in 21st Century

The quality of the education system depends on the quality of the teachers who manage the system (Sulaiman & Ismail, 2020). It was reported that teachers are very important in economic success and sustainability of education based on 21st century skills (Friedman, 2017). Martin (2018) stated that the key to 21st century classrooms is not technology, but evolved instruction. Thus, instead of the development of strong learning experiences that are compatible with personal traits and skills we expect students to acquire, if we focus only on the most creative

areas, the latest software or devices, were would only sustain the same educational values with more expensive tools.

In the 21st century teacher training, the approach to equip teachers with knowledge and to expect them to act based on a set of predetermined rules in instruction has changed. Now, the teachers are expected to respond to specific cases during instruction, to develop an adequate approach, and to acquire the competencies to associate this approach with other scientific approaches (Tutkun & Aksoyalp, 2010).

According to Saçlı (2005), an ideal teacher should not forget that "schools are for students". The teachers should focus on learning with students rather than teaching. The teacher should stick to "let us find this together" rather than "let me tell you this". The teacher should accept the fact that the future will be built on inquisitive learning methods and encourage the students to ask questions. The teacher should know that it would be beneficial to teach students what and where to find information rather than providing the information. The teacher should adopt a respectful and democratic personality towards everyone and especially the students; the teacher should be patient, tolerant, creative, flexible and friendly. The 21st century teacher should also be open-minded, transparent, sensitive to universal culture, environmental problems, and have strong communication skills, and be a good speaker and listener. The teacher should be open to intellectual activities. The teacher should acknowledge and care about the individual differences between the students and develop their imagination. Each student should increase student motivation, love them, and not scare them.

Palmer (2015) reported that teacher training that would aim to develop 21st century skills should be student-centered and integrated with information technologies. In other words, it was emphasized that pre-service teachers should acquire knowledge on information technologies, the skills to use these technologies and become active learners during training. Furthermore, pre-service teachers should acquire technical, knowledge management, communication, collaboration, creativity, critical thinking and problem solving skills, as well as ethical awareness, cultural awareness, flexibility, self-management and lifelong learning skills. In short, teachers should develop 21st century skills such as literacy, learning and innovation skills, knowledge, media and technology, life and career skills (Sulaiman & Ismail, 2020). Gümüş (2019) stated that the skills that teachers need to acquire in the 21st century included problem solving, critical thinking, creativity, cooperation, communication and leadership skills, similar to the students, as well as character development, professional ethics and active counseling competencies.

Figure 3. Teacher training in 21the century skills (e-kampus.com)

In Turkey, the Ministry of National Education updated the general competencies for the teaching profession in 2017 and the teacher skills described in this document were similar to the 21st century skills. Special field competencies were not determined for teachers in every branch. On the contrary, the whole document included field knowledge and field education competencies for each teaching branch. This document is summarized in Table 1 (MoNE-General Directorate of Teacher Training and Development, 2017):

Table 1. Teaching Profession General Competencies

A. Professional Knowledge	B. Professional Skills	C. Attitudes and Values
A1. Field Knowledge	B1. Educational Planning	C1. National, Spiritual and Universal Values
Has advanced theoretical, methodological and factual field knowledge that includes an querying approach.	Plans active instructional processes.	Observes national, spiritual, and universal values.

A2. Field Education Knowledge	B2. Development of Learning Environments	C2. Approach to the Student
Has a good command of the curriculum and pedagogical field knowledge.	Develops healthy and safe learning environments where active learning could take place and adequate instructional material for all students.	Supports student development.
A3. Regulatory Knowledge	B3. Management of Teaching and Learning Processes	C3. Communication and Cooperation
Acts per the regulations on duties, rights and responsibilities as an individual and a teacher.	Manages the teaching and learning processes actively.	Establishes active communication and cooperation with students, colleagues, family and other educational stakeholders.
	B4. Measurement and Evaluation	C4. Personal and Professional Development
	Employs measurement and evaluation, methods, techniques and tools adequately.	Self-evaluates and participates in personal and professional development activities.

It was reported that the 21st century student profile could not be acquired in the absence of teachers who implement the 21st century approach and set an example for students with their personality and behavior (MoNE, 2011). Thus, it is very important and difficult to train teachers who could instruct the planned education. The teacher training policies should prioritize the selection of the pre-service teachers based on certain principles and to provide them a good education to ensure the respect for the teaching profession in the society.

5. Learning in the 21st century

Students have different characters, goals, and needs. It is possible and desirable to provide individualized education. When allowed to make a choice, students would own learning and they strive more to learn. This is an ideal recipe for better learning outcomes (Palmer, 2015).

The lifelong learning, which is the most comprehensive form of 21st century learning, became more significant and was emphasized in several studies. Collins (2009) reported that lifelong learning is one of the most important competencies that educators, employers, governing bodies and generally all individuals should acquire in every stage of their lives, and lifelong learning incentive is a significant global challenge applicable to every profession and all aspects of life. To meet this challenge, various changes should be implemented in the instruction methods and learning styles. Teachers should adopt a more facilitating role in setting goals, identifying learning resources, and in-depth reflection on these factors, and students should take more responsibility. According to Collins, lifelong learning corresponds to self-regulated learning. Self-regulated learning, was defined as a process where students set individual learning goals and make plans based on these goals, select learning strategies, predict learning outcomes, analyze the process, check the study content, make judgments about learning difficulties, and reflect about these problems (Cheng, 2011; cited by Yildiz & Saban, 2015: 98). Self-regulated learning could be explained as knowing every aspect of one's own learning process and conducting active self-learning with adequate methods.

According to Chu, Reynolds, Tavares, Notari, and Lee (2017), who adopted a different approach to 21st century learning, it could be formulated with a combination of 3Rs and 7Cs. 3R reflects the common Rs in aRithmetic, Reading, and wRiting, while 7Cs represent the common Cs in the following concepts:

1. **C**ritical Thinking and Problem-Solving
2. **C**ollaboration, Teamwork, and Leadership
3. **C**reativity and Innovation
4. **C**ross-Cultural Understanding
5. **C**omputing and IT Fluency
6. **C**areer and Learning Self-Reliance
7. **C**ommunication and Media Fluency

21st century learning activities should also aim the acquisition of the 21st century skills. Thus, Collins (2009: 617) suggested certain activities:

- ✓ Participate in virtual universities and distance learning, access online libraries and remote databases for sponsored independent learning

- ✓ Participate in conventional learning update activities such as journal clubs, professional meetings, or self-study programs
- ✓ Enhance leadership skills as a volunteer in professional associations
- ✓ Develop new skills with experiential training, such as in technology or communication
- ✓ Find a mentor to be teacher, coach and support team member
- ✓ Read and reflect on reading, independently or with a mentor or peers
- ✓ Take coursework, or work toward an advanced degree

6. Instruction on the 21st Century

The dynamic interest in pedagogy as a tool to support the development of 21st century skills shifts towards problem-based and inquiry-based learning (Lu, Bridges, & Hmelo-Silver, 2014). Thus, classrooms are transformed from generally ineffective and boring pedagogy based on a teacher-oriented "I teach" approach, into "we learn" pedagogy, where the teacher learns with the students, specializes in content and implements the basic 21st century skills (Norris & Soloway, 2011). In this context, student-centered activities such as various projects, digital or active educational games, research-examination activities can also take place in the learning-teaching process.

In the 21st century, the need to create qualified human capital and develop skills for this purpose are more important than ever. While several countries included a set of new skills and competencies in the 21st century curricula, there is still little consensus on what those skills are. For example, the Singapore Ministry of Education defined 21st century individuals as confident, equipped, self-directed learners, engaged citizens and active participants. Finland defined these individuals as those with media and communication skills, cultural identity, participatory citizenship and personal growth oriented to ensure environmental responsibilities and individual well-being (Ministry of Education Malaysia, 2013).

21st century skills are theoretically comprehensible and desirable to fulfill the requirements of the century. However, it was determined that these skills were not easily implemented in instructional activities. Voogt, Erstad, Dede & Mishra (2013) attributed this fact to the lack of integration of these skills into the curricula and evaluation, the inadequate preparation of teachers, and the lack of overall systemic interest in the adoption of innovative instructional strategies and learning practices. According to them, several international studies demonstrated that although there was a consensus on the definition and acquisition of 21st century skills, instructional strategies have not often been implemented well in actual educational practices for the acquisition of the 21st century skills. Spector et al. (2016: 60) reported that new technologies that support individualized

learning and an intelligent education system that meets the needs of students, teachers and learning environments could support basic 21st century skills, especially critical thinking and problem solving.

21st century instruction and 21st century teacher's requirements include acceptance and implementation of an interdisciplinary approach. Thus, it was observed that STEM applications that were introduced in late 20th century (1990's) and were the pioneer of the interdisciplinary approaches are still implemented in the 21st century education. Originally referred to as SME&T in the United States National Science Foundation (NSF) reports (in the 1990s), the term STEM was coined in 2001, with the suggestion of NSF Education and Human Resources Director Judith Ramaley, who claimed that SME&T was an unpleasant term (www.tusasgokyuzzucocuklari.com). STEM reflects the first letters of Science, Technology, Engineering and Mathematics and was based on the combined employment of these disciplines as a philosophy (Elçiçek, 2020). STEM education is an integrated meta-discipline that aims to remove the barriers between these courses and focuses on both the design of solutions for complex contextual problems and innovation with current technologies (Kennedy & Odell, 2014). STEM education is also a standard-based, meta-disciplinary approach to instruction and learning that integrates science, technology, engineering and mathematics (STEM) education, and has a holistic approach to all included disciplines with a fluent content (Brown, Brown, Reardon & Merrill, 2011). According to Kennedy and Odell (2014), STEM education requires the integration of technology and engineering into science and mathematics curricula to encourage scientific research (Kennedy & Odell, 2014).

In the 21st century, educational tools are more advanced and contribute to diverse, individual and collective learning requirements of the students, and help teachers to improve active instruction. The properties of the Web 2 networks are presented below (www.egiteknoloji.com):

- ✓ *Edmodo*: It is an application where students and teachers could share material and conduct exercises in an online virtual classroom environment.
- ✓ *ClassDojo*: It is a gamification-based application where instant positive and negative feedback could be provided to students, teachers and parents in an online virtual classroom environment.
- ✓ *Kahoot*: It is a gamification-based application, where individual or group evaluation activities could be conducted, usually at the end of the class.
- ✓ *Popplet*: This is an entertaining, colorful Web 2.0 tool for concept mapping.
- ✓ *WordArt*: This is an entertaining Web 2.0 tool where colorful word clouds and word art could be created.

- ✓ *Scratch*: It is an android-based Web 2.0 jigsaw tool. Android applications could be designed easily with Scratch.
- ✓ *Canva*: It is a Web 2.0 tool to design visual material such as banners, logos, presentations, posters and brochures based on several templates.
- ✓ *Coggle*: It is a tool where conceptual and cognitive maps could be created with drag-and-drop.
- ✓ *Blogger*: It is a digital content development tool to publish reviews, articles, portfolios, websites and diaries on different topics.
- ✓ *Edpuzzle*: It is a Web 2.0 tool used to create interactive videos for YouTube or similar platforms by adding multiple choice and open-ended questions to videos.
- ✓ *Google Forms*: It is a Web 2.0 tool that allows the development of surveys and tests with short answer, multiple choice and open-ended questions.
- ✓ *Forvo*: It is a Web 2.0 tool that displays the pronunciation of English words in different accents and includes translations in different languages.
- ✓ *Thinglink*: The tool can create interactive visuals. For example, it allows adding a video, note or a website to any point on an image.
- ✓ *Storyboardthat*: A Web 2.0 tool that helps develop digital storyboards.
- ✓ *Google Jamboard*: A web 2.0 tool that allows individuals to create collaborative work on an interactive whiteboard online.

21st century teachers should be aware of such educational tools and learn and follow current approaches for the employment of these tools. Only then can they meet the requirements and be sure about their self-efficacy. Thus, they could teach effectively due to high self-confidence and motivation. Tutkun and Aksoyalp (2010) reported that professional training of the teachers should be continuous, and teachers should perceive it as a lifestyle. The 21st century teacher should be trained to acquire multidimensional skills to take position against changing conditions. Furthermore, they should be trained to acquire qualifications that would allow them to have an opinion and position on every topic associated with humanity and society.

7. Conclusion

The 21st century is a period that has been shaped quite rapidly compared to previous centuries, and in this direction, imposes too many responsibilities on its members. It is a period when individuals can have multiple skills, use multiple mental and physical activities in order to fulfill multiple occupations at the same time, and learn all these quickly in order to keep up with the era, in short, they need to be active in all aspects. In

this context, 21st century skills include high-level flexible thinking, critical thinking, problem solving, global citizenship, visionary leadership, innovation, collaborative communication, self-directed learning, digital literacy, financial and economic literacy, information and media literacy, scientific literacy, science and technology literacy, global (holistic) awareness skills. For the acquisition of these skills, especially the education system, schools, teachers, students and parents should be open to change and they must be constantly renewed. They should be aware of digital immigrantsi digital natives, x, xennials, y, z and alpha generations, and be responsive to their interests and needs for this age. In this direction, they should know and apply the learning and teaching activities, educational tools and pedagogical approaches of the age.

Within the context of lifelong learning, individuals, whether in the 21st century or in the following centuries, should constantly and willingly learn to fulfill the requirements of that age. Education and instruction plans at all levels from preschool to teacher training should be revised based on the requirements of the age. Thus, countries should adopt innovations rapidly and support education with technological, sociological, philosophical and financial resources.

As emphasized by Tutkun and Aksoyalp (2010), teacher training should be competitive in the international level in the 21st century. Teachers should be trained as individuals who are sensitive to all social problems and produce solutions for these problems and adopt a cross-cultural education that aims a democratic society. Because the students who need to be educated in this age; in addition to national culture and values, it is also aimed to be individuals who are equipped with universal knowledge and skills, have universal morals and culture within the framework of human rights, and are solution-oriented individuals, not problem makers.

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CHAPTER 8

THE SIGNIFICANCE OF THE NATURE OF SCIENCE IN SCIENCE EDUCATION

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1. Introduction

The concept of the nature of science, one of the significant topics in science education, is discussed in this chapter. Thus, definitions of the nature of science and dimensions of the nature of science are scrutinized. Since the nature of science is a vital component of scientific literacy, it is discussed in a separate section, and several approaches to the instruction of nature of science are introduced.

2. Science and the Nature of Science

The progress in scientific knowledge has affected all dimensions of social development since the antique ages. Advances in science always paved the way for developments in various fields such as technology, art, and philosophy, and ensured the dominance of humans over their environment. This dominance directly affects the economy and could increase social welfare. Thus, scientific advances are the main goal of all nations to become a global power.

Scientific development undoubtedly starts with understanding science. An individual who comprehended the general structure of science could accurately differentiate scientific and non-scientific phenomenon through scientific research, as knows the methodology to collect new scientific data. Literature review demonstrated that several authors attempted to describe science. According to Einstein, science is an effort to provide a balance between the chaotic sensory data (perceptions) and regular logical thinking (Einstein, 1940). According to Russell, science is an effort to determine the rules that connect the physical phenomena through observation and observational reasoning (cited by Bora, 2005). Çepni (2005) defined science as accurate thinking, searching the truth and knowledge, collecting and organizing systematic data with scientific methods, and efforts to understand and describe the universe. In addition to the processes of understanding, interpreting and synthesizing scientific data, Topdemir and Unat (2018) described the current science as an intellectual effort to discover the reasons for natural events, correlations between these events, to generalize, theorize these correlations, and to

predict the reasons and the time of future events based on the collected data."

Although the definitions of science differ, understanding science for all types of scientific knowledge would begin with a good grasp of its nature. Researchers described the nature of science with different definitions. Klopher (1969) described it as an awareness process, and included scientific inquiry and the developing structure of knowledge among the elements that form the nature of science. Showalter (1974) described the nature of science by emphasizing its variability, renewability, functionality, originality, integrity and experimentality. Among the more recent definitions of the nature of science, nature of science is the answers to questions such as what is science, how do scientists conduct research, and to what extent does science affect culture according to McComas and Olson (2000), Lederman (1992), based on the theory of science philosopher Kuhn, defined the nature of science as scientific epistemology, a way of knowing, scientific knowledge, and values and beliefs specific to the development of scientific knowledge. According to Ryder, Leach and Driver (1999), the nature of science is the description of data collection, interpretation and employment in research. Although there is no consensus on a single definition of the nature of science, there is an agreement about the attributes of the nature of science. Ruba and Anderson (1978) explained the nature of science with a six-component model. Thus, science could not have an ethical definition, it could not be considered as good or bad, it is influenced by human creativity, it is open to development, it should be created with a simple approach, it should be testable, and should include laws, theories and concepts. Similarly, Abd-El-Khalick (1998) suggested certain elements that should be known about the nature of science: Scientific knowledge is imprecise, experimental, subjective, partly a product of human imagination and creativity, and is affected by local social and cultural factors.

It was mentioned above that there was no consensus on the definition of the nature of science. Literature review revealed that the same was true for the nature of science dimensions. Erduran and Dagher (2014), reconceptualized the nature of science, questioned the "consensus" framework, and stated that the nature of science includes interacting cognitive - epistemological and social - theoretical components. McComas and Olson (1998) categorized the nature of science based on philosophical, social, psychological and historical foundations. Literature review revealed that the most frequently used classification of the nature of science was authored by Lederman, Abd-El-Khalick, Bell and Schwartz (2002) based on the dimensions of definition and function of science, scientific experimentation, scientific method, variability of science, scientific theory and laws, prediction and theoretical acceptances, scientific subjectivity,

society and cultural belongingness. In line with these dimensions (Lederman et al., 2002), NSTA (2000) stated that teachers and students should know that (a) scientific knowledge is reliable, but transient, (b) there is no single scientific method, (c) creativity plays a role in the development of scientific knowledge, (d) there is a correlation between theory and laws, (e) observation and inference are associated, (f) although science strives to be objective, the development of scientific knowledge always entails subjectivity, (g) and social and cultural environment plays an effective role in the development of scientific knowledge. Thus, it was considered that these dimensions, about which there is a consensus in the nature of science literature, should be presented in separate sections for comprehensibility.

3. Characteristics of the Nature of Science

In this section, the seven characteristics of the nature of the science proposed by Lederman et al. (2002) are discussed under the following headings: The tentative nature of scientific knowledge, Science and Subjectivity, Observation and Inference, Scientific Observation and Experimentality, Imagination and Creativity in Science, Scientific Method, and Theory-Law Hypothesis, including the common misconceptions about these characteristics.

3.1. The tentative nature of scientific knowledge

The conventional misconception about the variable nature of science is the claim that science and scientific methods provide conclusive evidence (McComas, 1996). Although scientific knowledge is reliable and long-term, it is not precise and absolute. Scientific knowledge that includes facts, theories and laws is not static. All types of scientific knowledge (hypothesis, theory, law) could change when new data is collected, previous studies are reinterpreted with different approaches, old studies are reconducted with different methods, and data are collected with advanced technologies (McComas, 1998). It was reported in The International Science Education Standards (National Research Council (NRC), 1996) that scientists change their ideas about nature when they discover new experimental data that does not conform to the current explanations. Although Faraday thought that ions would be released during electrolysis, Arrhenius mentioned that salt solutions could include ions without the presence of electric current. Thus, he suggested that chemical reactions in solutions would be the reactions between ions. This theory still holds true for weak electrolytes. Later, Debye proved that ionization was not partial, but complete (Gül, 2014).

3.2. Science and Subjectivity

The traditional misconception in this dimension is that all scientists are objective (McComas, 1996). Although science strives to be objective, the development of scientific knowledge always includes subjectivity. Theories, beliefs, and prior knowledge, education and experiences of the scientists affect their work (National Science Teachers Association (NSTA), 2000). Furthermore, the social and cultural environment plays an active role in the development of scientific knowledge. Scientists are influenced by expectations, value judgments, desires and social needs (Cited by Akerson et al., 2003; NSTA, 2000). Contrary to popular belief, observations and research are conducted to find solutions to certain problems. Scientific theories are employed to search for answers to these questions.

The differences between the definition of the species constitute a good example in this dimension. The species are defined with biological, morphological and nominalist approaches. Based on the biological species definition, species are defined as natural populations that include individuals who can exchange genes and have sexual reproduction capacity, while the morphological species definition includes the living beings similar to a particular form. Nominalist definition is based on the individual and claims that the concept of species was not derived from nature but exists only in human mind (Cited by Köksal, 2010). It could be observed that different scientists could disagree despite working in the same field.

3.3 The Difference Between Observation and Inference

Based on the literature, the students generally think that theories are discovered, they exist in the universe and scientists discover these based on the approach that equates knowledge and observation (Akerson & Khalick, 2003; Gül, 2014). Observation and inference are associated, but it could not be argued that they are the same. The systematic examination of an object, event or case to understand its characteristics is observation, while inference entails drawing conclusions about the factors behind the collected data, and to interpret these conclusions in research. Science depends on observations and inferences based on these observations. Inferences should be rational and consistent with the observations. The explanations of the scientists about the world originate in part in what they think and observe (American Association for the Advancement of Science (AAAS), 1993).

For example, the determination of the students in a classroom as unsuccessful is an observation, while interpretations such as they failed because there was insufficient light in the classroom or the socio-economic level of the students were low are inferences (Gül, 2014). While the

Rutherford's test, where he sent alpha particles to a metal plate and determined that most of the rays passed through the plate, was an observation, and his argument that there were large gaps in the atom was an inference based on the previous observation. Understanding the difference between observation and inference is a leading factor in making sense of several theoretical statements in science. Terms such as atoms, molecules, photons, magnetic fields, gravitational force in physics are the examples of these theoretical expressions. Also, the concept of species, or terms such as gene, electron and element are theoretical expressions in scientific theories (Abd-El-Khalick & Akerson, 2004; Hull, 1998).

3.4. Dependence on Evidence, Observation and Experiment

In inferences, scientists interpret the observational evidence with logic (Lederman et al., 2002). Experimentation is an integral part of the scientific process and the explanation of several natural phenomena that could not be determined with direct observation.

In scientific knowledge production, the employment of observation and experimentation is very important to distinguish the scientific and non-scientific. However, it should be suggested that scientific knowledge could not be based only on collected data; the interpretation of data is also very important in scientific knowledge production.

3.5. Imagination and Creativity in Science

It is one of the common misconceptions that science is a methodical process rather than a creative one (McComas, 1996). Although experimentation and observation are prerequisites for science, creativity and imagination are manifested in every scientific stage (NSTA, 2000). The scientist employs creativity and imagination at all stages, during the identification of scientific problems, conducting a research, and interpreting the findings, and even reporting to large masses (Lederman et al., 2001).

The selection of Drosophila by Benzer for the experiment on the genetic background of behavior (it can reproduce rapidly, mutants could be obtained quickly), and the design of fly chambers inspired by the countercurrent mechanism are the examples for this dimension (Gül, 2014).

3.6. Scientific Method

The review of scientific dynamics would demonstrate that there are different branches of science. Thus, the scientific research problems are also different in these fields. Different research problems should be solved by different methods (Chalmers, 1999).

Literature review demonstrated that various student groups believed in a universally accepted scientific method that should be followed step by step (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002; Akerson, Abd-El-Khalick, & Lederman, 2000; McComas, 1996;). One set of scientific methodology stages, which includes determination of the problem, observation, data collection, hypothesis, hypothesis-based predictions, testing the hypothesis, generalizations, development of the theory and the laws, is not scientifically practical (NSTA, 2000). Based on the nature of the problem, scientific knowledge could be achieved by systematic observations, determination of the correlation between phenomena, reviewing previous studies, or realistic consideration and interpretation of the facts subjectively.

3.7. Theory, Law and Hypothesis

Although hypothesis, theory and law are different types of scientific knowledge, previous studies demonstrated that students have a misconception that theories would become law in time or rejected based on inadequate descriptions (Dagher & Boujaoude, 1997; Gül, 2014; Parker, Krockover, Lasher-Trapp & Eichinger, 2008). Laws and theories do not have a hierarchical relationship; they are different types of scientific explanations (McComas, 1996).

Hypotheses are proposed provisional ideas about a phenomenon that need to be tested. Theory is a well-constructed internally consistent system of explanations that includes facts, inferences, scientific predictions and tested hypotheses based on theories, and has the power to explain certain aspects of nature or the physical universe (Abd-El-Khalick, 2006; NRC, 1996). Theories have the potential to generate questions and develop insights for new scientific research. Like all types of scientific knowledge, they are comprehensive propositions open to development and change (Taşkın, Çobanoğlu, Apaydın, Yılmaz & Şahin, 2008). Laws, on the other hand, are definitions of the correlations between observable phenomena (Lederman, 2006). Laws provide information about the mechanisms of the natural phenomena under certain conditions (Taşkın et al., 2007). Mendel's law of segregation is a generalization that claims that individuals born from two different offspring will be 100% hybrid and same as the other, provided that both offspring are pure. Boyle's Law explains the correlation between gas pressure and volume and the operation principle under certain conditions (Gül, 2014). Laws define the correlations between observable phenomena, theories are inferential findings about observable phenomena (Lederman, 2006). Kinetic molecular theory explains what Boyle's Law observed and defined. Furthermore, scientific models are the best examples of scientific theory and inference. Thus, there is no hierarchical relationship between law and theory. It is a textbook misconception that theories would turn into laws when solid evidence is available.

Furthermore, both laws and theories are universal, and like theories, laws are a dynamic type of scientific knowledge that could change.

The above-mentioned dimensions are the common consensus in the nature of science literature (Abd-El-Khalick, 2012; Aksoz, Kaya, Erduran, Akgün & Taş, 2016; Allchin, 2011; Aslan and Taşar, 2013; Bell & Schwartz, 2002; Bilican, Özdem - Yılmaz & Öztekin, 2014; Çakıroğlu, Doğan, Bilican, Çavuş & Arslan, 2009; Irzik & Nola, 2014; Lederman et. all., 2002) Certain recent studies offered new approaches in the nature of science through the expansion and criticism of the above-mentioned consensus. Allchin's Holistic Approach (Allchin, 2013) and the Family Resemblance Approach by Irzik and Nola (2014), which addressed the epistemic, cognitive and social aspects of science were among the alternative approaches.

4. The Significance of the Nature of Science in Science Education and Scientific Literacy

Understanding the nature of science allows the students to internalize scientific values and hypotheses in the process of scientific knowledge development (Zeidler, Walker, Ackett & Simmons, 2002). Furthermore, learning the nature of science helps students to comprehend scientific content and raise their awareness about scientific generalizations about the nature of science (Driver, Leach, Millar & Scott, 1997). The nature of science, which allows the comprehension scientific structure and the production and interpretation of scientific knowledge, is directly associated with scientific literacy (AAAS, 1993; Yalçınoğlu & Anagün, 2012).

National and international studies aimed to train science literate individuals in science education (AAAS, 2015; MoNE, 2013; National Research Council [NRC], 1996; National Science Teachers Association [NSTA], 2000). A science literate individual knows the basic scientific concepts and principles, could grasp natural diversity and harmony, but most importantly, could employ scientific knowledge and scientific thinking in daily life (AAAS, 1990). Harlen (2001) reported that individuals with high scientific literacy could make important decisions about their environment through the analysis and interpretation of their evidential knowledge.

Several definitions were proposed for scientific literacy. In general, scientific literacy is (Collette & Chiappetta, 1987; Weld, 2004);

- understanding the nature of science,
- acquisition of scientific operation skills,
- positive attitudes towards science,
- basic scientific knowledge,

- comprehension of the relationship between science and society.

Based on the above-mentioned definition, the nature of science constitutes an important component of scientific literacy. Several studies emphasized that a science education that includes the nature of science and all its dimensions would be beneficial for the acquisition of scientific literacy (NSTA, 2013; Lederman & Lederman, Bartos, Bartels, Meyer, & Schwartz, 2014; Şardağ et al., 2014; Özden & Cavlazoğlu, 2015).

Science educators identified three factors that affect and include science to improve scientific literacy (Bell, 2008). These factoes are presented in Figure 1, including explanations and examples. The nature of science is attributed to the third field and is less familiar and abstract when compared to other fields.

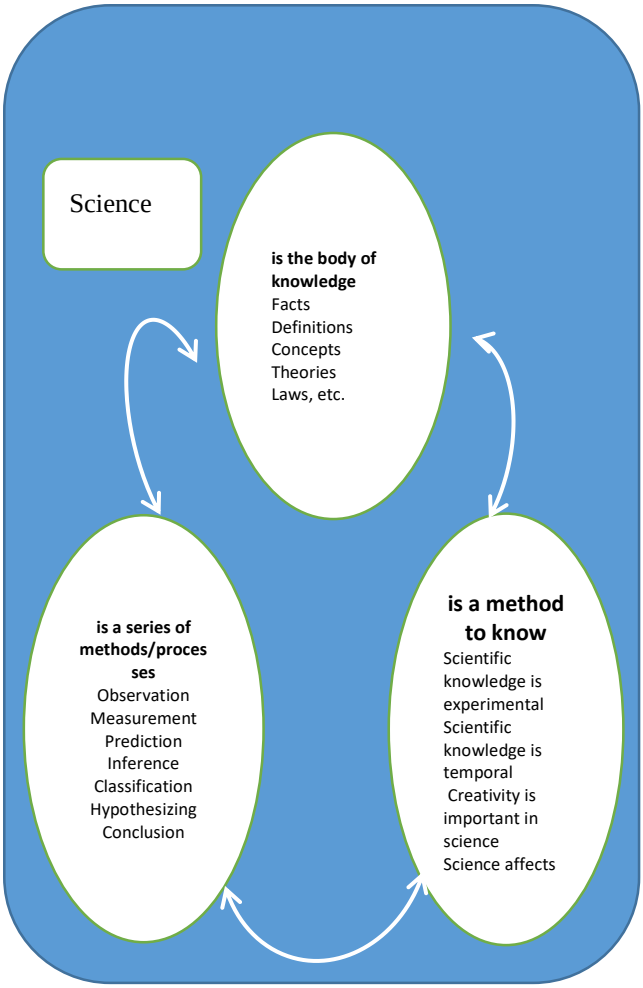

Figure 1: The Three Components of Science

The review of the science curriculum (MEB, 2018) revealed that it aimed to train science literate individuals and clearly emphasizes the scientific process skills, which are scientific methods presented in Figure 1. On the concept of the nature of science, the essence and spirit of the scientific process, it was reported the concept of the nature of science was defined in the 2013 curriculum; however, the curriculum was insufficient in nature of science dimensions (Kaya & Erduran, 2016; Özden & Cavlazoğlu, 2015).

5. Teaching the Nature of Science

Studies demonstrated that student groups, including primary education and pre-service teachers, had inaccurate (traditional) conceptions about the nature of science (Abd-El -Khalick, 2005; Abd-El-Khalick & Lederman, 2000; Alışır & Irez, 2020; Altındağ, 2010; Edge, 2008; Erdoğan, 2004; Gül, 2014; Khalick & Akerson, 2009; Küçük, 2006). This introduced a discussion on more efficient instruction of the nature of science, and 3 main approaches were proposed on the instruction of the nature of science: Historical, Direct and Indirect (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002).

5.1. Historical Approach

In this approach, students participate in activities that help them understand the development of scientific theories with a focus on historical examples, without ignoring the social and cultural developments in the relevant historical period (Solomon, Duveen, Scot & Mccarth, 1992). This approach characterizes science as a social convention and focuses on the impact of scientific ideas rejected by ancient societies on science, and the production of scientific ideas in a social and historical context to develop the nature of science concepts (McComas & Oslon, 2000). Two methods were proposed for the instruction of science history. In the first, scientific concepts are instructed first, and then the history of science is instructed based on these concepts. In the second, students conduct historical experiments associating these with scientific concepts, participate in historical discussions, read relevant articles and make inferences. It was reported that the second approach was better for the comprehension of the nature of science concepts (Clough, 2006; Matthews, 1994).

5.2. Implicit Approach

In this approach, students participate in activities such as research, projects, and experiments focused on scientific process skills. These activities increase the comprehension of the nature of science (McComas, 1993; Moss, Abrams & Kull, 1998). Thus, students engage in scientific

activities and internalize the nature of science concepts indirectly in this approach.

5.3. Explicit – Embedded – Reflective Approach

In this approach, accurate concepts about the nature of science should be clearly instructed directly to the students. Comprehension is not expected to occur as a by-product (Abd-El Khalick, 2001; Abd-El-Khalick & Lederman, 2000). Furthermore, student reflections in the activities they directly participate allow them to understand the concepts better in this approach.

6. Conclusion

The nature of science is an important field that leads to an understanding of the essence of science, accurate scientific methods, the developmental stages of scientific knowledge, the interpretation of scientific data, and the role of the scientists in these processes, paving the way for scientific development. It should be noted that the accurate understanding of the concept of the nature of science would pave the way for development in social sciences as well as the positive sciences. So much so that there is no difference between the investigation of the surface of Mars and observing riverbed formations and making inferences that once there was water on this planet and investigating migrants and making inferences about the psychological problems that these individuals experience. Because in scientific knowledge, the dimensions of the nature of science are present. Thus, it could be suggested that the concept of the nature of science should be the focus of not only the science courses, but all courses associated with science. Regardless of the instructional approach selected for the nature of science instruction at schools, it is very important to develop an accurate understanding about the dimensions of the nature of science that would serve as the essence of all scientific knowledge. It is obvious that humanitarian efforts, development and improvement of social welfare would only possible with scientific knowledge.

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