Current Studies in Educational Disciplines 2024

Editors

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PREFACE

In the age we live in, new knowledge is being produced and new inventions are being made every passing moment. This rapid change and development manifests itself in education systems as in all fields. This book has been prepared to provide a general perspective on educational research in 2024. We would like to thank everyone who contributed to the preparation and publication of the book.

December, 2024

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Ayşe Ceren ATMACA AKSOY

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Green Chemistry

The place where non-living and living elements interact in a balance that must be preserved is defined as the environment (Buckingham & Turner, 2008). Human beings, one of the living elements of the environment, have been affected and influenced by their environment. In the early times, the impact of this interaction on the environment was not destructive. However, especially during and after the industrial revolution, humans have caused destructive effects on the environment (Keleş & Hamamcı, 2002).

The industrial revolution has led to a growth in factories and transportation networks worldwide, which have improved people's lives in certain ways but had detrimental consequences on the environment. Growing industrialization processes have coincided with scientific and technological advancements, and the devastation brought about by negligent procedures has resulted in hazardous waste generation and environmental pollution issues (Liu et al., 2018; Ukaogo et al., 2020).

The chemical industry is one of the sectors that can cause environmental pollution and generate harmful waste materials. The existence of chemistry as a science dates back to 3000 BC. The science of chemistry has a very wide scope, from the production of medicines to the detergents we use for cleaning. However, when these processes are not organized in an environmentally friendly way, it has led to the production of harmful waste materials and pollution. There are various examples of this situation around the world. For example, in 1969, pollution in the Cuyahoga River in Ohio caused a fire. This situation necessitated legal regulations to clean up the river water (Anastas & Maertens, 2018; EPA, 2020). (Figure 1).

Figure 1. Cuyahoga River

As legal sanctions are seen to be insufficient, solutions have been sought worldwide. One of these solutions is the concept of green chemistry. When the dates showed 1991, the US Environmental Protection Agency (EPA) officially commenced the "Green Chemistry Program" as an alternative environmental program. Approximately 7 years later in 1998, John Warner and Paul Anastas explained the 12 basic principles of green chemistry and presented this understanding of green chemistry to the literature as a more comprehensive field (Anastas & Warner, 1998).

Green Chemistry as a Concept

When we look at the history of green chemistry as a concept, it is seen that it is not a very old one. The concept of green chemistry emerged in the 1990s from the idea of preventing pollution on site instead of cleaning up industrial pollution afterwards. In this respect, it can be said that it emerged as an alternative to the traditional pollute-clean approach. The essential point of green chemistry is the utilization of chemistry to prevent pollution. In a more comprehensive definition, green chemistry is the use and production of harmless chemical products and processes that do not harm the environment and do not cause pollution. In short, green chemistry is an understanding that establishes a link between the execution of chemical processes that do not harm human health and the environment, the production of products and environmental health (Hjeresen, 2000).

When the history of green chemistry as a concept is examined, it can be said that the first movement in the emergence of the understanding of green chemistry was the book titled "Silent Spring" penned in 1962 by Rachel Carson. One of the points emphasized by Carson in Silent Spring, which is a scientific book, is the destructive damage caused by some types of chemicals used on the environment and the consequences of this destruction. The warnings in the book attracted global attention. This book, which emphasized the seriousness of the destruction of the environment, is considered as the starting point of the main environmental movement (Sheldon, 2008).

In 1970, founded by President Richard Nixon, the establishment of the U.S. Environmental Protection Agency (EPA), an organization dedicated to improving the environment and human health, is an initiative towards green chemistry. One of the important decisions of the EPA was to ban the use of harmful chemical pesticides and DDT (Wilson & Schwarzman, 2009). Until the 1980s, environmentalist behaviors carried out by the EPA and the chemical industry were carried out on the basis of cleaning up environmental pollution. However, the global increase in concerns about environmental problems and pollution and the efforts to raise awareness and consciousness about the environment all over the world have led to a change in some understandings in chemistry science as in all fields. This change has focused on the prevention rather than the cleaning of pollution caused by chemicals that have negative effects on the environment and humans. Throughout the 1980s, meetings were organized by the Organization for Economic Co-operation and Development (OECD) to address environmental concerns. In these meetings, environmental targets were set and recommendations were made to prevent pollution. To achieve these goals, the Office of Pollution Prevention and Toxics (OPPT) was established by the U.S. Environmental Protection Agency (EPA) in 1988. This office was established to develop harmful chemicals used in industry in such a way that would be harmless to the environment and human health or to produce alternative harmless chemicals (Murphy, 2020).

The 1990s were years of significant developments in the appreciation of green chemistry as an official scientific field. The 1990 "Pollution Prevention Act" is one of the most substantial indicators of the acceptance of green chemistry (Linhorst, 2010). The conceptual definition of green chemistry was made in 1991. Anastas (1991) defined green chemistry as "designing chemical processes and products to decrease the use of hazardous substances and prevent waste" (Anastas & Williamson, 1996; Horvath & Anastas, 2007).

At the beginning of the 1990s, the European Community's Chemistry Council drew attention to the importance of green chemistry by publishing many articles on the theme of "Chemistry for

a Clean World." The first scientific meeting on this subject, a symposium on "Benign by Design: Alternative Synthetic Design for Pollution Prevention," was held in Chicago in 1994. The symposium was sponsored by the Division of Environmental Chemistry of the American Chemical Society (A. O'Connell, 1995).

Another development in the 1990s was the EPA Office of Pollution Prevention and Toxins staff, who coined the term green chemistry, laying the foundations for collaboration between management, industry systems, and science. Chemists P. Anastas and J. C. Warner outlined twelve basic principles of processes for developing chemicals that do not harm human and environmental health. P. Anastas also directed the EPA Green Chemistry Program, which focused on research and education. During this time, Anastas, together with EPA staff, worked with policymakers to recognize and promote green chemistry innovations (Krasnodębski, 2022; Maxim, 2023).

In 1995, the EPA got support from politicians to establish the Presidential Green Chemistry Challenge Awards (GCCAs) program to promote, support, and encourage useful new chemical technologies that prevent pollution harmful to human and environmental health (Anastas & Kirchhoff, 2002). In 1997, the University of Massachusetts established a PhD program in green chemistry. The program in Boston was the first green chemistry PhD program. In the same year, Dr. Joe Breen, an EPA employee, and researcher Dr. Dennis Hjeresen co-founded the Green Chemistry Institute (GCI). When the Green Chemistry Institute (GCI), a non-profit organization that shapes the concept and practices of green chemistry with the highest impact at the global level, was launched, Joe Breen was its director. Another important development in the understanding of green chemistry took place in 1998. In 1998, the book "Green Chemistry: Theory and Practice," written by Paul Anastas and John C. Warner, continued to guide the green chemistry movement by summarizing 12 principles of green chemistry (Clark & Minhas, 2003; Linthorst, 2010; Sheldon, 2018).

In the 2000s, it is seen that researchers around the world have adopted the principles and goals of green chemistry. In 2001 and 2005, Nobel Prizes were awarded to studies in the field of green chemistry, which is one of the biggest indicators that the green chemistry movement has attracted global attention and adoption (Dicks & Batey, 2013; Keinan, 2021).

Despite all these developments, it would not be correct to say that the effects of green chemistry are highly visible in the entire chemical industry today. Today, the raw materials used to make chemicals are obtained from fossil resources at a high rate. It seems possible to change this situation with the recognition of the field of green chemistry all over the world and the integration of its applications into all systems, especially education systems (Gerçek, 2012).

Principles of Green Chemistry

Green chemistry is a field that aims to eliminate unsafe, unhealthy conditions and pollution by reducing the production or use of products that have the potential to harm human and environmental health in the synthesis, design, production, and use of chemicals in different areas. A number of principles are applied in this process. These principles are considered as an indicator of the progress made in the field of green chemistry and as principles that guide future studies (Anastas & Warner, 2000). The outlines of these 12 basic principles, known as the basic principles of green chemistry, were established in 1998 by P. Anastas and J. C. Warner. These 12 principles are a guide to be applied at all stages, starting from the raw materials used in the chemical industry to the efficiency of the process, the safe execution of the processes, the toxicity and biodegradability of the products, and the reagents used in the process (Anastas & Eghbali, 2010). These 12 principles are listed in Figure 2 (Abdussalam-Mohammed et al., 2020).

Figure 2 : *The Twelve Principles of Green Chemistry*

The first of the 12 fundamental principles of green chemistry is the principle of prevention. The prevention principle aims to prevent pollution at the source instead of polluting first and then cleaning up the pollution. This principle is based on the understanding of not creating waste at all instead of cleaning it up after it is created (Tang et al., 2005).

The second principle is "atom economy". Barry Trost defines the ideal reaction as containing all atoms of the reagents. Atom economy also aims to avoid waste by ensuring efficient use of the raw materials used in the process and the formation of fewer by-products (Trost, 1995). The principle of atomic economy is based on the understanding of designing synthetic methods that maximize the level of integration of all materials used in chemical processes into the end product (Dicks & Hent, 2015).

The third principle of green chemistry is the tenet of "less hazardous chemical synthesis." This principle is based on the understanding that in all possible fields, methods should be developed to produce and use substances that do not harm the environment and therefore human health (Hjeresen et al., 2002). One of the best examples of this principle is the production of cumene (Anastas et al., 2000).

The fourth principle is the "design of safer chemicals." According to this principle, chemical products should be manufactured with high functionality to contain the least amount of toxic substances. The concept of safe chemicals is to minimize the toxicity and potential for harm without reducing the functionality of the chemical (Morales et al., 2020).

The fifth principle is "safer solvents and auxiliaries". This is based on the principle that auxiliaries used during a reaction should be used harmlessly and in small amounts. Auxiliaries used in chemical processes can sometimes have the potential to seriously harm human and environmental health, so it is better to use them sparingly and safely (Beach et al., 2009; Kerton & Marriot, 2013).

The principle six is "design for energy efficiency". According to this principle, energy needs should be evaluated and minimized by considering economic and environmental factors. In the context of this principle, if chemical transformations are designed to require less energy, the negative effects of this energy need on the environment will be reduced (Horvath & Anastas, 2007).

The seventh principle of the twelve fundamental principles concerns the "use of renewable feedstocks." According to this principle, feedstocks used in chemical processes should be renewable. In the context of this principle, feedstocks should be renewable, not consumable. Thus, sustainable and environmentally friendly systems that do not create negative pressure on the environment can be created (Clark et al., 2006; Verma et al., 2024).

The eighth principle is to "reduce derivatives." According to this principle, by-products, i.e., derivatives, used in chemical processes should be reduced as much as possible. Derivatives in chemical processes can lead to waste generation or the use of additional markers. Reducing derivatives will be a step that positively affects the atomic economy (Erökten, 2006; Kottappara & Palantavida, 2020).

The ninth principle of green chemistry is "catalysis". According to this article, the use of catalysts in chemical processes reduces waste production. Catalysts that can be used many times also positively affect the reaction efficiency (Söğüt & Celebi, 2020).

The tenth principle is an item on the end-of-function transformation of chemical products: "Design for Degradation." According to this principle, chemical products should not degrade into harmful products that have a negative impact on the environment. Chemical products can persist in the environment for many years by showing resistance in their own structure at the end of the process. The accumulation of these chemicals can have toxic effects for some species. This is undesirable for green chemistry. In the understanding of green chemistry, chemical products should turn into harmless decomposition products at the end of the process (Demir, 2017).

The eleventh principle is a clause on "real-time analysis for pollution prevention." Waste or pollution generated by chemical processes is undesirable for green chemistry. According to this principle, in order to prevent waste or pollution at the end of chemical processes, methods should be developed to monitor and control the entire process (Hjeresen et al., 2000; Yayayuruk & Yayayuruk, 2019).

The final principle of green chemistry, the twelfth principle, is the idea of "inherently safe chemistry for accident prevention." According to this principle, substances used in chemical processes should be selected by taking into account their accident-causing properties. In the understanding of green chemistry, the substances utilized in chemical processes should be selected in such a way that minimizes the potential to cause accidents. In this context, inherently safe chemicals should be produced and used (Mulholland et al., 2000).

Reflections of Green Chemistry Practices on Science Education

It is a necessity to integrate the understanding of green chemistry, which aims to make chemical processes more sustainable by reducing chemical use and waste generation, which are risk factors, into education and training environments. Today, many different industries and fields are operated with chemistry knowledge. In this context, not only chemists, engineers, or chemistry teachers but also all individuals who will be involved in different professional groups should be equipped with basic green chemistry knowledge. In this case, it is possible to widely integrate the understanding of green chemistry into all levels of education, from primary education to higher education and even post-graduate education (Eilks & Rauch, 2012; Nurbaity et al., 2016).

In order for individuals to acquire competencies for green chemistry, it is of great importance to spread educational practices for green chemistry fields. MacKellar et al. (2020) listed green chemistry competencies in their study. According to the researchers, an individual who has received green chemistry education will generally know the nature of chemicals and will have the necessary skills to choose which material is more sustainable. They will have the knowledge and skills to select or design safe chemicals that do not have a negative impact on the environment and human health. In addition to this knowledge, they will be able to carry out studies to reduce the footprint of chemicals on the environment in cooperation with other professional groups. In short, they will be able to have the necessary knowledge and design the necessary tools for the selection, design, comparison and evaluation of environmentally friendly and safe materials that serve human health in all chemical processes. Will be able to manage chemical processes in accordance with the green chemistry approach.

Science education is a discipline with various sub-disciplines such as physics, chemistry, biology, environmental education, astronomy, and earth science. Science education is not a field where only the information of these disciplines is presented. It is an active, dynamic, and, in short, a living science in which the knowledge of sub-disciplines is adapted to daily life by establishing interdisciplinary connections. It offers active, living by doing, and lifelong learning by providing students with the opportunity to apply their knowledge in depth and with laboratory applications (Abell et al., 2013). Due to its transdisciplinary nature and the sub-disciplines it contains, all kinds of applications and developments for environmental health are also a subject of science education (Abbasi et al., 2018; Kurnaz, 2019).

One of the fields of education where green chemistry studies are reflected is science education. Chemistry education, which includes knowledge and practices related to chemical science with innovative approaches, and environmental education, which includes knowledge and practices related to environmental health and sustainable development principles, are disciplines within the scope of science education. In this context, green chemistry practices should be provided to individuals in areas such as environmental education, chemistry education, and laboratory applications within the scope of science education (Karpudewan et al., 2009; Sjöström et al., 2016).

Andrew Dicks' studies can be given as an example of the integration of green chemistry into educational environments. Dicks (2009) aimed to make chemistry experiments carried out in laboratory applications in accordance with the principles of green chemistry. In this context, Dicks designed experimental setups in which water could be used as an alternative to solvents used in organic chemistry reactions and organized laboratory applications in accordance with the principles of green chemistry. Thanks to this arrangement, experiments that take a long time and carry risks such as potential exposure to chemicals can be carried out in a short time and in risk-free environments (Demir, 2017; Dicks, 2011).

Another example is the work of Julian R. Silverman. In his study, Silverman (2016) focused on the use of non-renewable energy resources, which is one of the biggest obstacles to ensuring environmental sustainability. In this context, Silverman suggested the use of biobased products

that can be defined as sustainable in accordance with the principles of green chemistry instead of petroleum-based products in laboratory applications. The researcher designed experimental processes involving biobased products to be used in laboratories. In this way, he both drew attention to the use of renewable energies and transformed laboratory practices into a greener and more sustainable laboratory.

Another example of the reflections of green chemistry in laboratory studies is the preference for citral reactions as chemical selectors. Citrals are natural substances found in flower extracts that give off a pleasant odor. The preference of these substances in laboratory applications eliminates the bad odor and risk potential of chemical substances to be used as an alternative. Thus, students will be able to work with natural substances in their experimental processes, and laboratories will be safer and more sustainable (Cunningham et al., 2010).

The fact that the science of chemistry is based on experimentation poses many problems, such as the harm of chemical substances and wastes to human and environmental health. Both individuals and the environment need to be protected from the toxic effects of chemical substances. Although the foundations of the green chemistry concept that emerged in this context officially date back to the 1990s, it is a new concept for the education and training curricula of many countries. In our country, the foundations of chemistry education are laid with science education. The foundation of individuals' knowledge and skills about chemical processes and laboratory applications is shaped in the process of science education. This situation shows the importance of an innovative and effective science education. In this scope, it is very crucial to integrate green chemistry practices into science education not only in the field of chemistry or environmental education but also in all processes where chemicals are used and wastes are generated. Students who receive a green chemistry education integrated into science education will take care not to use chemicals harmful to human and environmental health throughout their lives. In addition, they will be able to access risk-free alternatives of these chemicals in the light of the knowledge they have through laboratory applications within the scope of science education. Thus, by preventing the use of harmful chemicals, they will contribute to human and environmental health and, moreover, to the efforts for a sustainable world.

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Socioscientific Issues in Science Education

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What are Socioscientific Issues?

Science, technology and society have interacted with each other from past to present. Developments in science and technology aim to meet the needs of society (Sadler and Zeidler, 2005; Topçu, 2015). Technology contributes to the development of science by putting the goals of science into practice. Therefore, it can be said that science, technology and society are in a reciprocal and dynamic relationship with each other. The reciprocal relationship mentioned here may seem harmonious at first glance. However, science is inherently open to change and subjective (AAAS, 1993; Lederman, Abd-El-Khalick, Bell, & Scwartz, 2002). Technology that emerges as a result of scientific knowledge may produce some negative or controversial results (Oliveira, 2017). The technology that emerges as a result of scientific knowledge can lead to some negative or controversial results (Oliveira, 2017). This situation can lead to scientific knowledge and technological developments not being accepted by the society or to disagreements. Although they are scientific and technologically based, controversial issues that contain contradictions such as positive/negative, necessary/unnecessary, useful/harmful have given rise to socioscientific issues. In these dilemmas experienced by individuals regarding a subject, issues that are open to discussion, include dilemmas, do not have a definitive answer, are complex, open-ended and closely related to science, are called socioscientific issues (SSI) (Sadler, 2004; Topçu, 2021). In order for a subject to be considered a socioscientific issue, its most basic characteristics must include dilemmas and be based on a scientific basis (Topçu, 2015).

Socioscientific issues are issues that have scientific and social foundations, are controversial issues due to their dichotomous nature, include moral and ethical aspects of society, and have gained national and global dimensions. The term controversial is a situation where there is no single truth in calling it a controversial issue and that creates conflict between individuals by allowing for disagreements. For example; the advantages and disadvantages of establishing nuclear power plants in a region have become a controversial issue. While some segments of society welcome it positively in terms of economic development, energy production, reducing external dependency and providing employment opportunities if the necessary safety measures and conditions are provided when establishing nuclear power plants, some segments have become a subject of discussion in terms of accidents that may occur in nuclear power plants, radioactive waste, and environmental

pollution.

Sadler and Zeidler (2005) have expressed the characteristics of socioscientific issues as follows:

- Socioscientific issues have a scientific basis and contain discussion and contradiction in their nature,
- By their nature, they cause disagreements within society and await resolution,
- They do not have a single answer and are open to evaluation from more than one perspective,
- They are social and scientific issues that contain ethical and moral dilemmas.

Similarly, the general characteristics of socioscientific issues are listed by Ratcliffe and Grace (2003) as follows:

- They are current issues based on science and real life.
- They are based on science and are usually within the boundaries of scientific knowledge.
- They include poorly structured problem situations.
- They are usually media articles (TV, newspaper, internet, radio).
- They do not have exactly correct answers.
- They indicate local, national and global dimensions. These dimensions are also related to political and social content.
- Includes some cost-benefit analysis where risks affect values.
- Considers sustainable development.
- Includes values and ethical reasoning.
- Provides understanding of probability and risk.
- Erduran and Jimenez-Aleixandre (2007) stated the aims of discussions on socioscientific issues as follows:
- It can contribute to the increase of the level of knowledge.
- It can contribute to the social awareness of knowledge since they are issues that contain dilemmas.
- It can help students produce solutions to a complex issue they encounter in daily life.
- It can contribute to students' development of concepts related to the nature of science through socioscientific issues.
- It can contribute to students' training as good debaters and enable them to use their knowledge when making decisions on a subject.

When the definition and characteristics of socioscientific issues are taken into account, a model (Figure 1) can be created regarding socioscientific issues (Topçu, 2021).

Figure 1.: *Modeling of Socioscientific Issues*
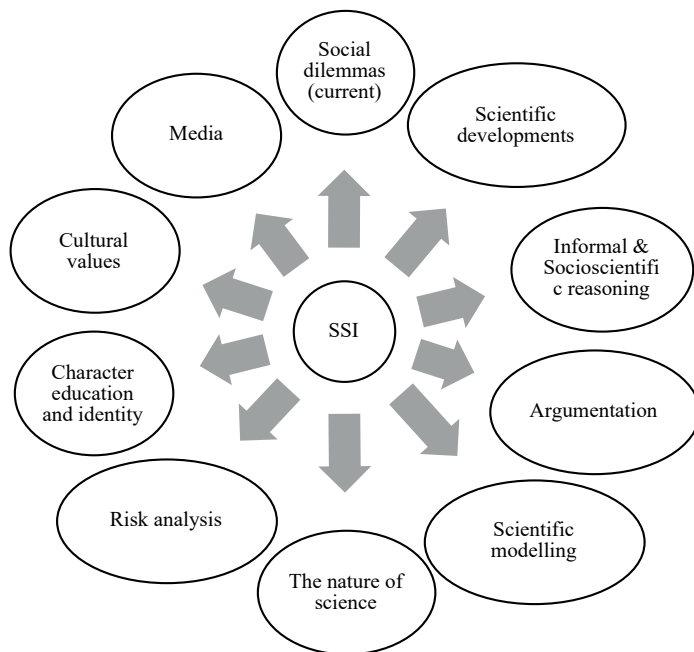
Considering the characteristics of SSI and the age of science we are in, interest in SSI continues to increase day by day, and socio-scientific issues have been included in international reform documents and national programs based on the vision of raising scientifically literate individuals encountered in daily life, in terms of developing scientific literacy, students' scientific thinking habits, reasoning and decision-making skills (AAAS, 1993; MEB, 2013; 2018; NRC, 1996). The National Research Council (NRC) advocates that socio-scientific issues should be discussed, analyzed, and included in school curricula (NRC, 1996). When we look at the last twenty years, SSIs have been integrated into science curricula in different countries or have been attempted to be integrated. Many countries, especially the United States (US) and England, have accepted the importance of SSIs in science education and have begun to include them in their curricula (Topçu, 2019). Turkey is among the countries that have included SSIs in science curricula.

The Place of Socioscientific Issues in Science Education

Towards the end of the twentieth century, many researchers reached a common conclusion that science subjects could be better understood by considering the inclusion of social problems in science courses (Topçu, 2008; Zeidler et al. 2005). Among the main purposes of including socioscientific issues in the science curriculum; developing scientific literacy, making science interesting within society and turning it into a tool that can solve a problem situation in daily life are of great importance. In addition, in learning environments where socio-scientific issues are used, it contributes to the development of analytical thinking, scientific literacy, argumentation, questioning, analysis, inference, decision-making skills with a critical perspective, ethical and moral reasoning skills and behaviors in students (Evren & Kaptan, 2014).

When we look at the historical development of socio-scientific issues, we can say that they have developed in a historical process that complements each other since the 1970s. In the 1970s and 1980s, the Science-Technology-Society (STS) approach was adopted and integrated into the

curriculum in many countries (Zeidler et al. 2005). The most important point in this approach was that it clearly revealed the relationship between science, technology and society. However, over time, it has been subject to some criticisms regarding not emphasizing the views and experiences of students enough and not drawing attention to ethical issues and the moral and character development of students (Zeidler et al., 2005).

In the 1990s, due to the rapidly developing and changing scientific and technological developments and the developments in science and technology, the Science-Technology-Society-Environment (STSE) approach, which is a more comprehensive approach than the Science-Technology-Society approach, was adopted. Although this approach is a more advanced version of the STS approach, the environmental dimension was added, and the issue of the environment being affected by scientific developments, which scientists frequently bring up and conduct research on, was evaluated as a popular approach and the role of the environment was questioned in more detail (Yapıcıoğlu, 2020). Although the STS approach is more comprehensive and draws attention to moral and ethical issues, it has come across studies arguing that it is inadequate because it does not emphasize argumentation, the nature of science, and the cultural and emotional development of students (Lee, 2012).

In the 2000s, SCI, which includes topics such as cloning, genetically modified organisms, stem cells, genome projects, organ and tissue transplantation, which are particularly notable in the field of genetics, has begun to become the focus of attention of many researchers. In addition, with the spread of nuclear power plants all over the world, the threat of privacy by technological tools, and the rapid development and change in many areas such as ecological degradation, a new approach called "Socioscientific Issues" has been adopted by science education researchers with the increasing criticism on STS and STSE approaches (Zeidler et al., 2005; Topçu, 2019). Although the foundation of SSCs dates back to the 1980s, in the 2000s, SSCs took on a broader conceptual framework than the STSE approach. When we look at the content of socio-scientific issues, in addition to all the components included in the STSE approach; the nature of science, scientific claims and arguments, social, emotional, personal, political and ethical dimensions, as well as individuals' decision-making based on their personal beliefs and experiences (Zeidler & Sadler, 2023). The interaction of these three approaches is shown in Figure 2 (Topçu, 2021).

Figure 2. *Science-Technology-Society Based Approaches*
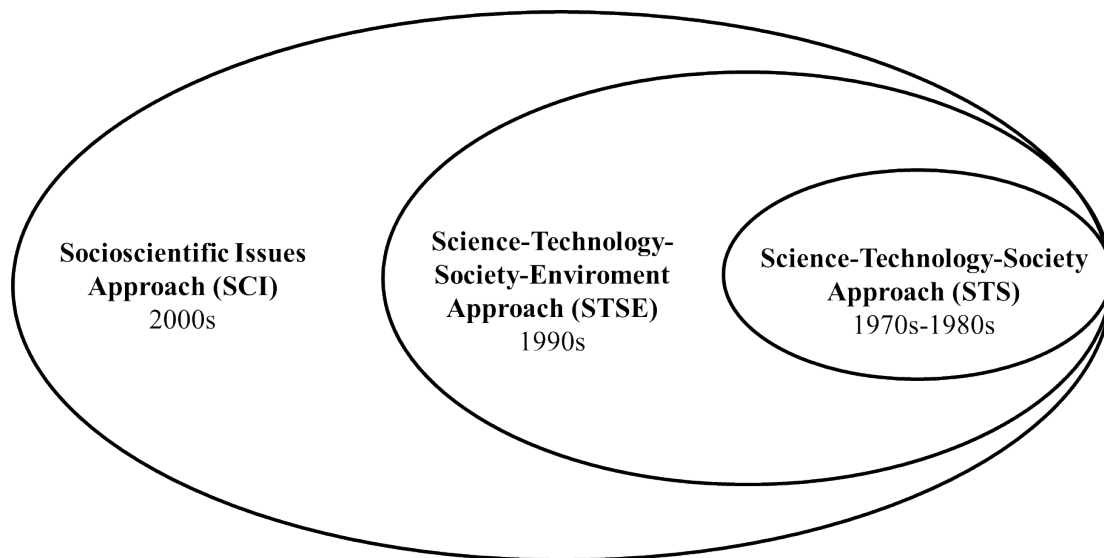
SSI have reconceptualized the science-technology-society approach and added a different dimension by focusing on the personal experiences and beliefs of individuals as well as the science and technology dimension (Topçu, 2021).

The Importance of Socioscientific Issues in Science Education

In order for a society to develop and grow, it needs individuals with high reasoning skills, critical thinking and decision-making skills. Socioscientific issue-based teaching is of great importance in enabling students to reason and gain awareness about a topic that concerns society through discussions and by addressing it from a critical perspective. By addressing socioscientific issues within the scope of science education, students are enabled to learn science lessons by making better sense of them and to feel closer to the topics (Pedretti, 1999).

The development of knowledge-based decision-making skills about socio-scientific issues that we encounter in daily life and that are of close interest to society is an important part of science education, which is based on the vision of raising scientifically literate individuals (Çavuş, 2013; Topçu et al. 2014). The development of individuals' decision-making skills regarding any socio-scientific issue is of great importance in the development of scientific literacy (Driver, Newton, & Osborne, 2000). According to some studies, it has been stated that learning environments based on SSIs make learning about a scientific subject that individuals find boring or uninteresting more interesting, increase their motivation to learn information, and exhibit positive attitudes towards science education (Akşit, 2011; Topçu et al., 2014).

There are some reasons underlying the integration of SSI into the science curriculum. In addition to supporting the cognitive development of the individual in the teaching of SSI, it also develops the individual emotionally and morally. These subjects, by addressing a problem situation in daily life, allow students to understand such subjects better and at the same time make them interesting.

Some studies in the literature support the idea that SSI teaching increases students' motivation

for science (Zeidler and Sadler; 2005). It has been stated that SSI teaching improves students' understanding of the nature of science (Khishfe and Lederman, 2006; Walker and Zeidler, 2007). In addition, there are studies indicating that argumentation and reasoning skills also develop during the SSI education because individuals enter a process where they create claims and arguments about controversial issues using scientific data (Sadler and Zeidler, 2005; Dawson and Venville, 2009; Wu and Tsai, 2011; Öztürk and Yılmaz Tüzün, 2017; Akbaş and Çetin, 2018). Therefore, socio-scientific issues contribute to students' decision-making skills by developing their responsibility in economic, political, social, health and ethical issues related to science, their ability to look at events with a critical eye and to make conscious decisions (Gülhan, 2012). Examples of these topics that we hear frequently in daily life and that are included in the science curriculum are; some applications of genetic engineering, genetically modified foods (GMO), gene therapy and cloning, organic agriculture, global warming, nuclear energy and thermal power plants, renewable energy sources (HES, wind, solar), environmental problems, space studies, space pollution, organ donation and transplantation, and endangered species, and many other topics have been addressed as socio-scientific issues.

When studies on socio-scientific issues are examined, socio-scientific issues in the international literature focus on two themes: purpose and tool. There are studies on the use of SSIs as a tool (Topçu, Sadler & Yılmaz-Tuzun, 2010) and as a purpose (Klosterman & Sadler; Topçu, 2010). As can be seen in Figure 3, in studies where SSI are used as a purpose, the aim is to gain the gains in the curriculum within the scope of socio-scientific issues and the students' knowledge levels, perceptions and self-efficacy are emphasized. However, in studies where they are used as a tool, the students' affective development (raising awareness, creating a value system and giving conscious reactions), the development of their scientific practices, as well as their argumentation and reasoning skills are examined (Topçu, Muğaloğlu & Güven, 2014).

Figure 3. *Themes of Studies on Socioscientific Issues in Science Education*
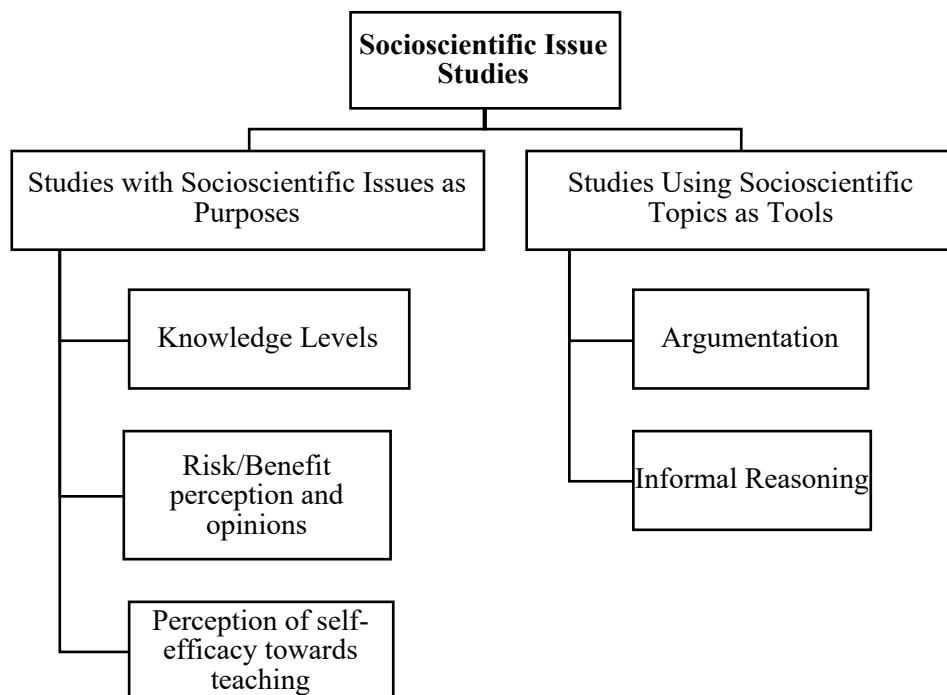
The Place of Socioscientific Issues in Science Curriculum

According to Sadler (2004), SSIs contribute to the blending of science-related concepts that closely concern society with technological information. By associating science concepts with technology, the concepts of "science", "technology" and "society" have emerged and this concept has had an important share in shaping the curriculum of some countries. Later, "environment" was added to these three concepts and the Science, Technology, Society and Environment (STE) approach emerged (Hodson, 1994). In our country, this approach has been added to the science curriculum by the Ministry of National Education since 2004 and it has been stated that it has great importance in terms of raising students as "science literate" by understanding the relationship between these four concepts.

Socioscientific issues have been included indirectly, if not directly, in the Science and Technology Curriculum, which has been implemented in our country since the 2004-2005 academic year, among the general objectives of which are "to ensure that students realize the social, economic and ethical values related to science and technology, personal, health and environmental problems, take responsibility for them and make conscious decisions".

While socio-scientific issues were a subheading within the Science-Technology-Society-Environment outcomes in Turkey before 2013, they were included in the curriculum as a title with the program studies in 2013. In the 2013 Science Curriculum, attention was drawn to the use of SSI in terms of generating scientific thought in the form of "developing scientific thinking habits using socio-scientific issues" and it was included in the teaching objectives (MEB, 2013). In the draft program prepared in 2017, the emphasis was continued in the Science-Engineering-Technology-Society-Environment learning field. In the 2018 Science Curriculum, attention was

drawn to the fact that among the general objectives, "to develop reasoning, scientific thinking habits and decision-making skills using socio-scientific issues" (MEB, 2017; 2018). Within the scope of the changes made in the 2024 Science Curriculum, learning outcomes are; In addition to field-specific skills, conceptual skills, dispositions, social-emotional learning skills, values and literacy skills, it is aimed to effectively support the multi-faceted development of students. In this context, among the general objectives of the science curriculum, the importance of socio-scientific issues is emphasized as students are "interested in socio-scientific issues, doing research, questioning, developing innovative solutions with an interdisciplinary perspective" (MEB, 2024).

Among the main objectives of the science course curriculum is to raise scientifically literate individuals who are aware of their responsibilities in solving social problems encountered in daily life, who have creative and analytical thinking processes, and who produce alternative solutions to a problem (MEB, 2018). They are also expected to be curious about socio-scientific issues, conduct research, and develop innovative solutions with a questioning perspective (MEB, 2024).

The socio-scientific issues covered in the science curriculum are of great importance in terms of developing scientifically literate individuals, who are aware of their responsibilities regarding the social problems they encounter in daily life, and who produce alternative solutions to solve the problem, and their decision-making and reasoning skills. In addition, the inclusion of socio-scientific issues in the curriculum can contribute to students' curiosity about the subject, their research, and their development of solution suggestions with an inquisitive perspective.

Socioscientific issues have become one of the topics researched by many researchers in science education, both nationally and internationally (Driver, Newton, & Osborne, 2000; Zohar & Nemet, 2002; Ratcliffe & Grace 2003; Sadler, 2004; Sadler & Zeidler, 2005; Wu & Tsai, 2007; Topçu, 2008; Topçu, Sadler, & Tüzün, 2010; Dawson & Venville, 2010; Soysal, 2012; Kutluca, 2012; Öztürk, 2013; Evren & Kaptan, 2014; Akbaş & Çetin, 2018; Tüzüngüç, 2019, Sicimoğu, 2020; Ocak, 2022; Toktaş & Genç, 2023).

According to Simonneaux (2007), the advantages provided by socio-scientific issues used in science education;

- It improves scientific process skills and analytical thinking skills,
- It establishes a connection between scientific literacy and social life by increasing the function of scientific literacy,
- It contributes to creating social awareness,
- It enables the conceptualization of the nature of science,
- It improves argumentation skills.

In summary, addressing socio-scientific issues in science education contributes to the formation of individuals' perceptions of the nature of science, their awareness of social issues, their ability to think critically by developing reasoning and decision-making skills, the ability to look at a subject from different perspectives, and the development of higher-order thinking skills by developing

analytical thinking skills.

Teaching Framework for Teaching Socioscientific Issues

Various researchers have stated some criteria and elements to be considered regarding the use of socioscientific issues in teaching environments. Evren and Kaptan (2014) have expressed the elements to be considered in the selection of socioscientific issues planned to be used in the classroom environment as follows:

- Does the selected topic have scientific content?
- Does the selected topic contain a dilemma?
- Does it cover the interaction of science-technology-society?
- Is the selected topic open-ended and does not have a single answer?
- Does the answer vary depending on the students' value judgments (moral-ethical)?

Once a specified socio-scientific topic is selected, it is of great importance whether this topic matches the achievements in the curriculum, whether it is suitable for the pedagogical level of the students and whether it is suitable for the general objectives of the curriculum.

Sadler (2011) and Presley et al. (2013) developed an exemplary framework for teaching socioscientific issues based on theoretical and applied research on SSI in the literature. This socioscientific issue-based framework example that has been prepared is a roadmap that can be easily used by science teachers in both the SSI literature and in the teaching of SSIs in classroom environments (Topçu, 2015). When we examine this curriculum closely, we see that it consists of 3 basic components. These are design components, student experiences and teacher characteristics. The graphical representation of the framework of these components is shown in Figure 4 below.

Figure 4. *Graphical Representation of the SSI-Based Teaching Framework (Presley et al. 2013)*
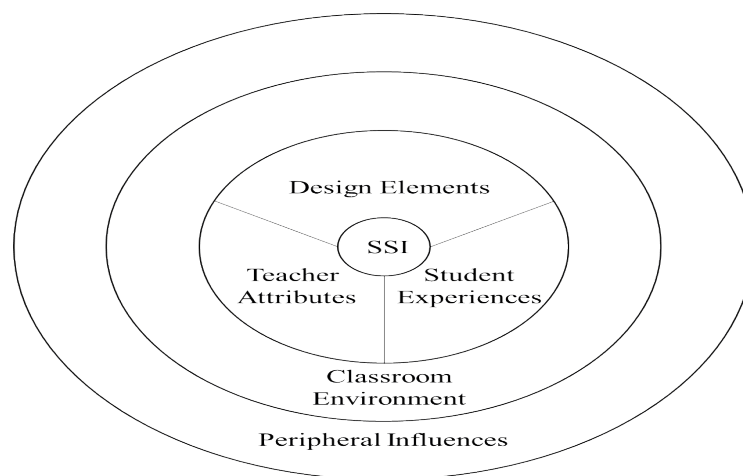
As can be seen in the figure, these three basic components are framed by the classroom environment and the largest circle surrounding all these components from the outside is called Peripheral (External) effects.

Design Elements

The design component, which is one of the basic components of the SSI teaching framework, has four basic features.

- When SSI is included in the teaching process, it should first be structured around a controversial topic
- The selected controversial topic should be presented at the beginning of the lesson
- It should direct students to higher-order thinking skills such as argumentation, reasoning and decision-making
- The process should be concluded by associating the new topic that the students have learned with the scientific topic they have learned before.

Apart from these features, the teaching environment can be enriched by using media to relate the activities carried out in the classroom to real life and technology to increase learning experiences (Sadler et al., 2017).

Student Experiences

One of the important components for effective SSI-based teaching is the student experiences-learning experiences component. It basically has four features.

- Students should be given the opportunity to gain high-level thinking skills such as argumentation, reasoning and decision making
- Scientific ideas and theories related to the SSI being studied should be addressed
- Students should collect and analyze data to support their claims during the process
- Discuss or evaluate the economic and political dimensions of SSIs by creating awareness.

In addition, although it is not mandatory to associate a socio-scientific issue with the nature of science and evaluate it with ethical dimensions, it is suggested that opportunities can be given if the content of the subject is appropriate. For example; While it is not possible not to discuss the ethical dimension of genetic engineering, which is a socio-scientific issue, it is not mandatory to associate or discuss the nature of science and ethical dimension of another SSI (Sadler, 2011; Topçu, 2015).

Within the scope of the SSI-based curriculum, it will contribute to the development of students' discussion skills and awareness of the issues they encounter in daily life. In addition, it contributes to the development of communication and empathy skills in the classroom environment, as well as the development of higher-order thinking skills such as critical thinking, reasoning, and argumentation (Hacıoğlu and Kartal, 2022; Topçu, 2021).

In teaching socio-scientific issues, students can form cooperative groups to serve a common purpose, interact with each other, and support their mutual learning, as well as contributing to the development of communication skills. According to Ratliffe & Grace (2003), there are certain skills and competencies that are expected to be gained by students at the end of the process by including

socio-scientific issues in teaching. These are:

- Understand the concept of science and how to share the scientific process,
- Understand the nature of decision making at a societal and personal level,
- Know the scope of socio-scientific issues from a local, global and national perspective,
- Understand and demonstrate the nature, strengths and limitations of socio-scientific news in the media,
- Be able to make benefit and harm analysis regarding possible situations,
- Be able to make ethical and moral judgments regarding socio-scientific issues,
- Recognize the current and changing nature of socio-scientific issues,
- Understand the nature of environmental sustainability,
- Be able to make probability and risk analysis,
- Understand and evaluate the deficiencies in evidence,

In order for students to gain the specified competencies in the classroom environment, it is of great importance to create a classroom environment where students and teachers feel safe and respectful, by allowing students to work collaboratively. In order to effectively implement design components and student experiences in SSI-based teaching, a supportive classroom environment and an effective teacher role are first necessary (Sadler, 2011).

Teacher Attributes

It consists of the basic features that SSI regional education must have in order to successfully achieve its purpose;

- Whether the necessary technical features and social dimensions related to the quoted SSI are known,
- The teacher should be able to honestly state this situation, which does not have enough climate regarding the subjects he/she deals with,
- The teacher should be in the role of the person who provides authority in the classroom environment, should direct everyone in the right direction as a guide and should be able to do this,
- He/she should be prepared and ready for the performances that are the amount of storage in the classroom regarding the SSI dealt with

In the classroom environment, teachers are expected to guide students to reach the correct information and also lead the discussions in the classroom environment rather than being the ones who provide authority. Since the nature of the SSI is open to discussion, it is more difficult to manage the discussion environment in the classroom compared to the traditional teaching classroom environment. In this regard, the teacher should make good classroom plans accordingly and start the discussions after providing environments where students can freely express their supportive or opposing views (Atabey, 2016).

Bell & Lederman (2003) grouped the skills and knowledge that teachers should have about socioscientific issues under three questions:

- Does the teacher have comprehensive knowledge about the science in the content of the socioscientific issue?
- Does the teacher have comprehensive knowledge about how the socioscientific issue can enhance students' ethical and moral development?
- Does the teacher have comprehensive knowledge about argumentation and how to evaluate the quality of arguments?

There are a number of difficulties that teachers face in teaching SSI. Some of these difficulties are; students are not patient with their friends due to their age and interrupt them and talk all at once, teachers do not want to allocate enough time to these topics, especially in classes where end-of-year exam anxiety is high, and teachers have problems with impartiality due to the contradictions and discussions inherent in SSI (Chen & Xiao, 2021; Öztürk & Yılmaz-Tuzun, 2017; Seçgin, 2009). Ratcliffe & Grace (2003) also emphasized that teachers' lack of sufficient knowledge of socioscientific issues and adequate teaching strategies on controversial issues, some teachers' failure to accept that social issues are a part of the science curriculum, and insufficient time allocated to the ethical and moral dimensions of socioscientific issues due to the programs' intensive conceptual knowledge, cause socioscientific issues to be rarely included in the classroom environment.

It is of great importance for teachers to have sufficient in-depth knowledge in order to implement socio-scientific issues in the classroom in accordance with the general objectives of the science curriculum. Therefore, teachers should be equipped with this competence in teacher training programs and these competences should be developed and imparted to teachers through necessary in-service training.

Classroom Environment

Socioscientific issues have great importance among the objectives of the science curriculum. Important school environments that contribute to the achievement of the desired objectives of the curriculum are classrooms. Each classroom has its own equipment, a classroom climate created with its teachers and students. This classroom environment plays an important role in which students share their ideas with their friends, develop their ideas and sometimes change their ideas in the light of scientific information. Therefore, in order for the curriculum to achieve the desired objectives, it is important to create a classroom environment where students can easily express their ideas, support their interaction with each other and feel safe while expressing their ideas. A classroom environment that includes opposing ideas by nature and requires each student to respect each other's ideas on the subject and offers an interactive learning environment should be created (Topçu, 2019).

The second layer of the SSI-based teaching framework is the classroom environment. The classroom environment affects the basic components of SSI-based teaching, which are design,

learning experiences, and teacher characteristics. The classroom environment;

- To have high expectations for student participation and where students feel comfortable
- An interactive collaborative learning environment between teachers and students throughout the process
- When different opinions on the subject are put forward, both students and teachers should respect each other
- A learning environment should be created where teachers or students feel safe (Topçu, 2017).

It is important that the physical conditions of the classroom are equipped to respond to the learning activities of the students. In a classroom that is suitable for creating discussion environments due to the nature of socio-scientific issues and is sufficient in terms of class size, an environment will be provided for students to think better and express their ideas comfortably, allowing socio-scientific issues to be discussed as necessary (Yapıcıoğlu &Kaptan, 2018). In addition, it is important to minimize the negative situations that may be caused by the physical environment that prevents students from hearing each other in discussions that take place in the classroom.

Peripheral (External) Influences

The peripheral effects located in the outermost layer of the SSI-based teaching framework scheme cover and affect both the three basic layers (design, teacher characteristics and student experiences) and the classroom environment components.

In order for SSI-based teaching to be implemented;

- Teachers should be supported and encouraged,
- Easy access to materials should be provided,
- The implemented teaching program should have the necessary flexibility
- Local SSI should exist and awareness should be created on this issue
- Effective communication and cooperation should be provided with the relevant administrators
- Necessary relationships should be established between the implemented teaching program and SSI-based teaching

Various studies have been conducted on the development of a socio-scientific issue-based teaching model and current SSI-based teaching models. Another research team that provides detailed information and research on how to do SSI-based teaching, Friedrichsen, Sadler, Graham, and Brown (2016), designed a SSI-based teaching model (Figure 5).

Figure 5. *Model for Teaching Socioscientific Issues (Friefrichsen et al., 2016)*
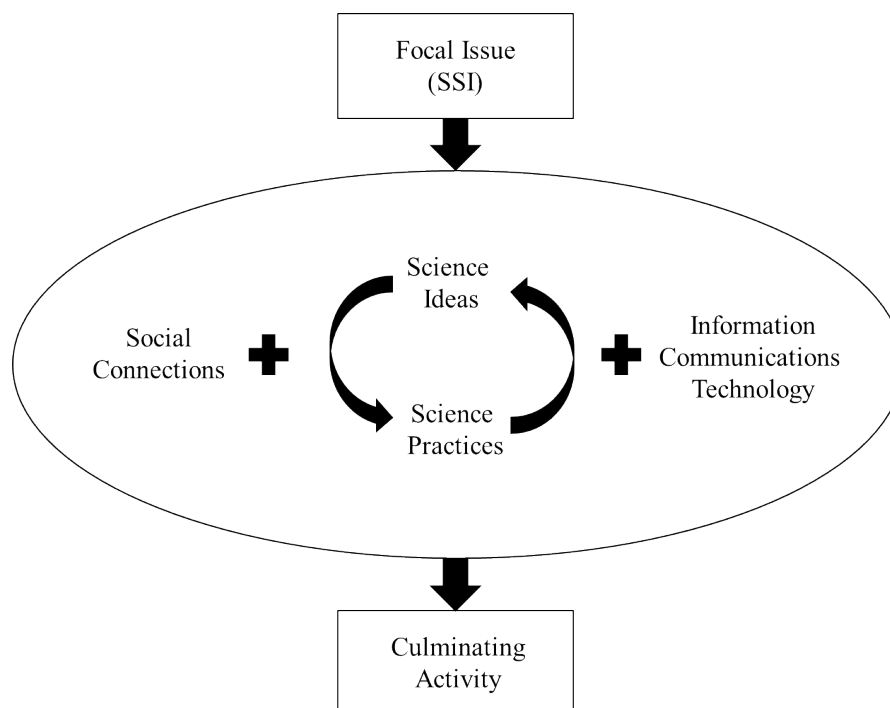
According to this model, it is recommended to start the lesson with the SSI, which is called the focus topic, at the beginning of the lesson or unit and to allow for a detailed analysis of the SSI. In the next stage, it is a model that advocates that there should be active interaction between the student and the teacher during the process where students are included in applications such as discussion, argumentation and scientific modeling regarding scientific ideas in the lessons. Again, it is recommended that students be given the opportunity to actively use information and communication technologies during the process. In the last stage, students are asked to develop a policy regarding the relevant SSI as a synthesis of all they have learned and a poster is prepared about the SSI and what is learned during the lesson or unit is reflected on the poster at the synthesis level (Topçu, 2021).

Within the scope of a study conducted on developing a SCI-based teaching model, the SSI teaching and learning model was updated (Sadler, Foulk, & Friedrichsen, 2017). This model, shown in Figure 6, has the same main idea as the previous models, but it has been made more current by adding some parts. Unlike the previous models, this teaching model has been updated to include the US National Science Standards (NGSS, 2013). In addition, three-dimensional learning of science education (science subject matter knowledge, interdisciplinary concepts, and science-engineering applications) has been associated with socioscientific reasoning. Another difference is that reflections from these three dimensions are observed in the learning outcomes and the learning outcomes are specifically stated (Sadler et al., 2017).

Figure 6. *Updated Socioscientific Issues Teaching and Learning Model (Sadler et al., 2017)*
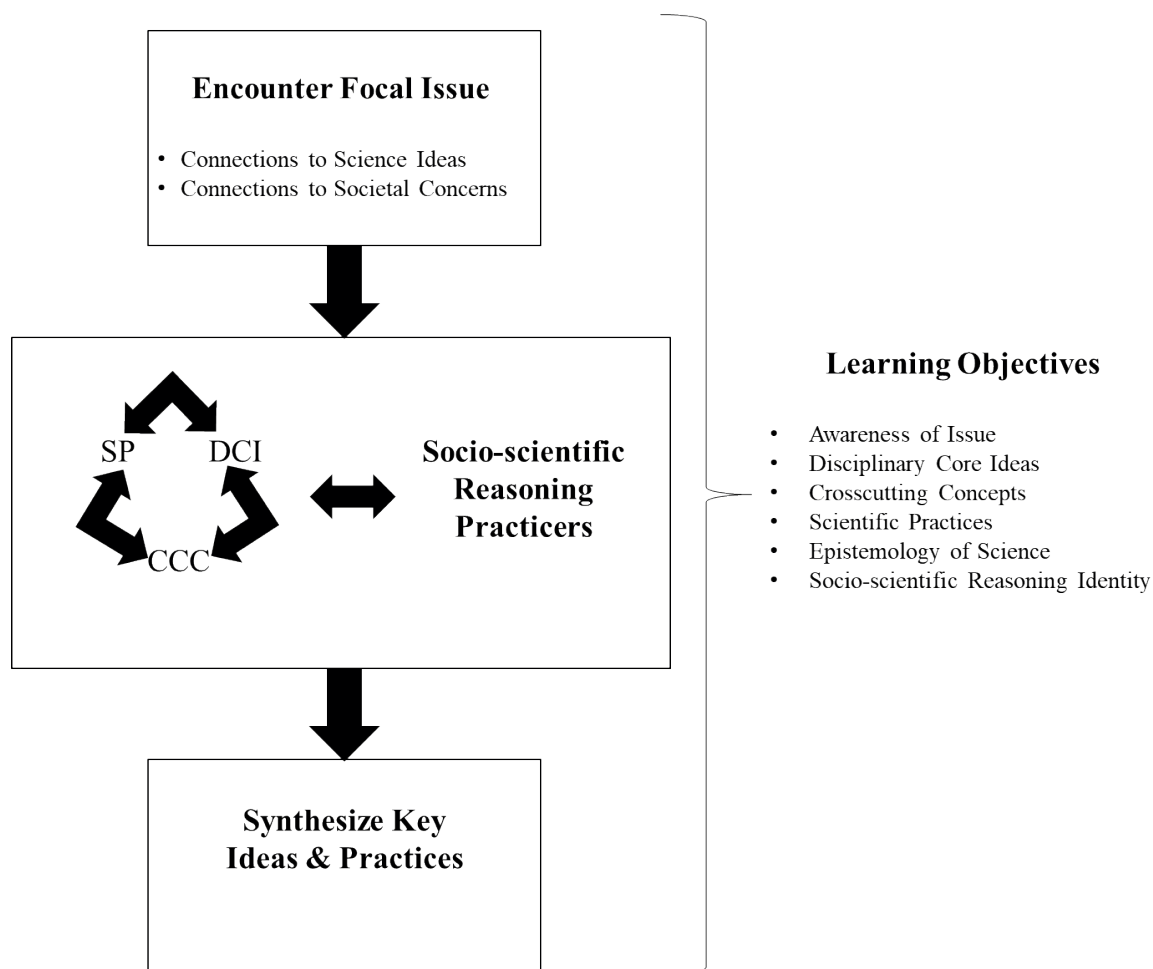
The Relationship Between Socioscientific Issues and Informal Reasoning and Argumentation

Sadler (2004) states that informal reasoning has an important effect on students' coping with problem situations involving socio-scientific issues. Informal reasoning includes reasoning about the pros and cons, advantages and disadvantages, causes and consequences of some events (Zohar and Nemet, 2002). According to Sadler (2004), informal reasoning is defined as a person's ability to evaluate and analyze a complex event rather than simple solutions to that event. Socioscientific issues are ideal topics for applying informal reasoning because they are open-ended, unstructured, and debatable problems (Kuhn, 1993). In this process, individuals consider the pros and cons, risks, and benefits of socioscientific issues from a different perspective and contribute to their evaluation. Therefore, informal reasoning can be considered as a suitable approach for socioscientific issues (Sadler, 2004; Topcu, Sadler, & Tüzün, 2010).

Individuals use informal reasoning skills to resolve any socio-scientific issue they encounter (Shaw, 1996; Sadler & Zeidler, 2005). Informal reasoning can be summarized as the process in which individuals discuss reasons and consequences and establish valid arguments in order to make logical explanations for a particular event they encounter in their daily lives (Sadler,

2004; Zohar & Nemet, 2002). Informal reasoning, individuals can use cognitive and affective processes on issues with uncertain outcomes (Topçu et al., 2010). In this process, students present a claim, a justification, a counterclaim, and evidence to refute the counterclaim (Yılmaz Tüzün, 2013). Students can use the information found in socioscientific scenarios presented to them for discussion, their personal beliefs (Wu, 2013), their experiences, or the information they obtain on any platform (Shaw, 1996) while presenting their arguments in the context of informal reasoning. Socioscientific issues are solved with informal reasoning, and informal reasoning is explained through argumentation (Sadler, 2004).

Figure 7. *Relationship of Informal Reasoning with Socioscientific Issues and Argumentation (Sadler, 2004)*
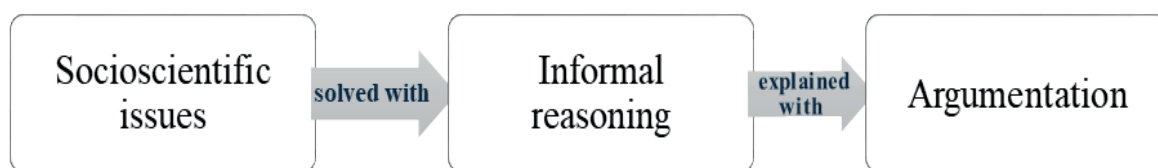
Socioscientific issues are inherently controversial, ill-structured, and complex. For this reason, informal reasoning and arguments in support of claims are important in solving socioscientific problems and making critical decisions (Means & Voss, 1996). A student who wants to make a decision or make a judgment about a socioscientific issue uses informal reasoning skills to create an argument and uses various decision-making mechanisms in this process (Urhan, 2016).

Characteristics of Informal Reasoning

Two basic features stand out in the evaluation of informal reasoning. These are; informal reasoning quality and informal reasoning patterns at Figure 8 (Topçu, 2021).

Figure 8. *Informal Reasoning and Classification*
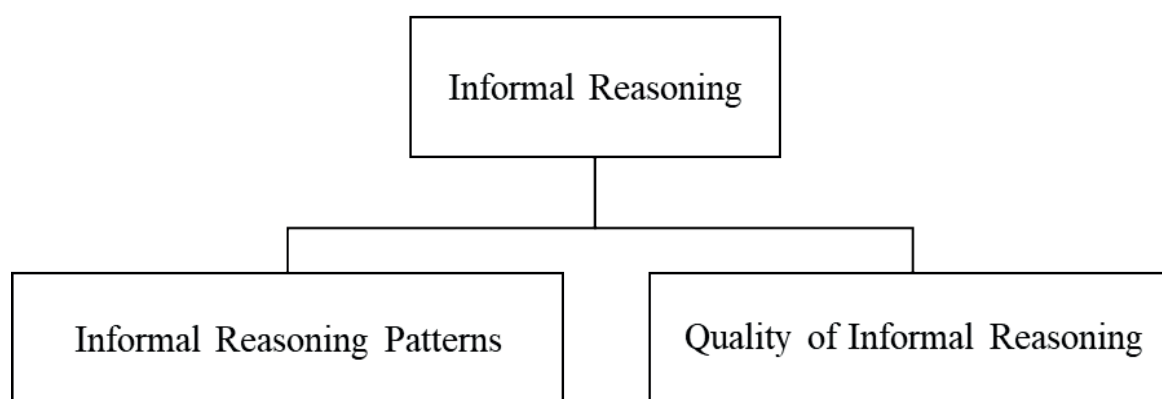
a) Informal Reasoning Patterns/Modes

Various informal reasoning patterns/modes of students have been used in the literature about socio-scientific issues. These modes are presented in the Table 1.

Table 1. *Classification of Informal Reasoning Patterns*

Researcher(s)	Patterns/Modes of Informal Reasoning
Patronis, Potari & Spiliotopoulo (1999)	Ecological, Social, Economic and Practical/Realistic
Yang & Anderson (2003)	Social, Scientific and Equally Organized Reasoning (Both Scientific and Social)
Sadler & Zeidler (2005a)	Intuitive, Rational and Emotional
Wu & Tsai (2007)	Ecological, Social, Economic, Scientific and Technological Focused Arguments
Öztürk & Leblebicioğlu (2015)	Scientific-Technological, Ethical-Aesthetic, Socio-Economic and Ecological
Öztürk & Yılmaz-Tüzün (2017)	Types of Risk, Political-Social, Ecological, Economic, Scientific and Technology Oriented

b.) Quality of Informal Reasoning

According to Topçu (2021), another of the two basic features in the evaluation of informal reasoning is the quality of informal reasoning. In science education literature, the quality of informal reasoning is represented as argumentation (Driver, Newton, & Osborne, 2000). Informal reasoning generally refers to the sum of both affective and cognitive processes in the solution of complex events. It is also stated that argumentation is the form of expression of informal reasoning (Yılmaz-Tüzün, 2013; Topçu, 2021). Therefore, argumentation is an important concept.

Argumentation has an important role in understanding science-based models, applications and concepts in science education. Argumentation in science education can be defined as establishing a connection between claims and data using justifications or evaluating claims through theoretical evidence (Enderun & Jimenez- Alexindre, 2007). With the understanding of the importance of argumentation, there has been a significant increase in argumentation applications in science education from the 1980s to the present (Cavagnetto, 2010). The use of the argumentation method in science classes is considered important because it allows individuals to use their knowledge about a subject they have learned at school during discussions and to express their ideas comfortably and freely while defending them (Çapkınoğlu, 2015).

According to Sadler (2004a), the reason why socioscientific issues are used as content in the argumentation process is that the nature of socioscientific issues contributes to the creation of argumentation from multiple perspectives. It is also stated that individuals are aware of some discussions on socioscientific issues they encounter in daily life and that they contribute to the creation of more complex arguments by making scientific learning meaningful by taking an active role in producing solutions to the problem situation (Osborne et al., 2004). It has been argued that in this way, not only the application of scientific knowledge but also critical thinking is developed

by looking at scientific claims and arguments from multiple perspectives. (Puig and Jiménez-Alexandre, 2011).

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Supervision in Counsellor Education

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Introduction

Counselling education is a dynamic process where theoretical knowledge and practical experiences come together; in this process, supervision stands out as a critical component that supports the professional development of counsellors, maintains ethical standards and ensures the well-being of clients. Supervision in counsellor education is a guidance process carried out to improve the professional skills of counsellor candidates, to learn ethical standards and to gain experience in working with real clients (Borders & Brown, 2022). In this process, an experienced supervisor (usually a graduate level educated and experienced counsellor or therapist) guides the counsellor candidate, provides feedback and supports his/her professional development (Henderson, 2018).

The history of supervision in counselling

Supervision is recognised as a vital process for building a skilled workforce and delivering certain services to a high standard. Its historical roots date back to ancient times when skills and knowledge were passed on through apprenticeship from a more experienced practitioner (Žorga, 2002). The first traces of supervision are found in mythological figures such as Chiron, known for his healing. More systematic documentation of medical supervision begins with the teachings of Hippocrates (Larson, 2017). The first formal examples of supervision date back to the 19th century. In this period, social workers directed voluntary work offering moral cures to the poor. Freud's regular analyses at the Zurich clinic in the early 20th century helped to link supervision with modern psychotherapy (Watkins, 2013). However, it has been suggested that Freud applied indirect therapy through his father in his work on Little Hans, and therefore this work can be considered as counselling rather than supervision (Fisher & Greenberg, 1985).

Since the 1930s, the need for supervision has increased and systematic models have started to be developed. Carl Rogers made this practice more observable and teachable by including the use of recording devices in supervision processes. (Miller & Moyers, 2021). His human-centred approach contributed to making supervision more supportive and interactive. In the 1970s, the structuring of supervision processes gained momentum and researchers such as Bernard and Goodyear defined supervision as an educational process (Watkins, 2012).

The systematic models developed in this period pioneered supervision to become a fundamental component in the field of counselling (Davys & Beddoe, 2020). Nowadays, supervision is used as a fundamental tool to increase the professional competence of counsellors and to ensure the well-being of clients (Campbell, 2013). In the United States, supervision is required by accreditation

organisations such as CACREP, while in Turkey this process is becoming increasingly important (Kalkan & Can, 2019). Especially supervision practices of universities are expected to be generalised (Özyürek et. al., 2021).

Supervision in counselling has a long historical development process and plays a critical role in supporting the professional development of counsellors as well as maintaining ethical standards (Corey et. al., 2020). In the future, supervision is expected to become more systematic, scientific and standardised. (Gonsalvez & McLeod, 2008). This process will make significant contributions to individual and social well-being by increasing the competencies of counsellors.

Main Functions of Supervision

Supervision is a fundamental process that supports the professional development of professionals working in the field of psychological counselling and therapy and strengthens the well-being of clients (Howard, 2008). The functions of this process cover a wide range from professional development to the protection of ethical standards (Davys & Beddoe, 2020). Effective implementation of supervision results in the benefit of both professionals and clients.

Supervision allows therapists to develop their knowledge and skills (Grater, 1985). This process increases professional competence by encouraging the application of new theories and techniques (Falender & Shafranske, 2007). One of the main elements of this function is that therapists in the training process review their practices through case analyses and feedback (Beidas & Kendall, 2010). Supervision helps therapists to act in accordance with professional standards (Falender et al., 2004). In supervision sessions, ethical dilemmas are discussed and solution strategies are developed. This plays a critical role in protecting client rights and ensuring compliance with ethical rules (Corey, et al., 2020). Supervision, which increases the emotional and professional resilience of therapists, is an important tool in stress management and reducing the risk of burnout (Skovholt & Trotter-Mathison, 2014). Supporting therapists enables them to be more effective in the therapeutic process (Wu & Levitt, 2022).

Supervision offers the opportunity to strengthen therapists' communication skills (Kadieva & Williams, 2023). Working on therapeutic relationship management and effective communication techniques makes therapists' professional interactions more efficient (Thompson, 2015). Supervision sessions provide a learning environment where therapists evaluate their practice through case presentations and receive feedback from supervisors. This process helps therapists to identify their strengths and areas of development (Kilminster & Jolly, 2000). Group supervision allows therapists to learn from different perspectives by sharing experiences with colleagues. This format is valuable for peer support and professional co-operation (Borders, 1991). Supervision enables therapists to realise their professional practices in accordance with the required standards (Milne, 2009). Supervisors assess therapists' accountability and quality of practice through methods such as structure-process-result analysis (Kraus et al., 2011).

Effects of Supervision

Supervision has a critical role in improving client care. Meta-analyses have shown that regular and planned supervision is associated with more favourable outcomes in clinical conditions such as depression (Mor-Barak et al., 2009). The strengthening of the therapeutic alliance and adaptation to the biopsychosocial model are the main reasons for these effects (Gilbert, 2019)

Sources indicate that supervision is effective in increasing therapists' competences, skills and self-confidence (Tan & Chou, 2018). Systematic reviews emphasise that supervision processes are critical for effective training and professional development (Kilminster & Jolly, 2000). Supervision increases client satisfaction by increasing the effectiveness of the therapeutic process and improves the quality of professional practice (Wheeler & Richards, 2007). It also supports the professional performance of therapists by promoting compliance with ethical standards (Pope et al., 1987).

Supervision is an essential component of both client care and therapist development. Effective supervision practices increase the competence of therapists and provide better outcomes for clients. This process is indispensable for maintaining and improving professional standards in counselling and therapy (Rønnestad & Skovholt, 2003). A more systematic and comprehensive implementation of supervision in the future will make significant contributions to the advancement of the field.

Supervision Models

Supervision is carried out with various models to support the professional development of practitioners in the field of psychological counselling and therapy (Davys & Beddoe, 2020). These models determine the structure and functioning of the supervision process. Below, widely accepted supervision models are summarised:

Developmental Models: These models shape the supervision process according to the developmental stages of the counsellor (Holloway, 1987). For example, in the model developed by Stoltenberg and Delworth, supervision strategies are determined according to the experience level of the counsellor (Stoltenberg & McNeill, 2011). The developmental stages of the counsellor affect the content and form of supervision (Stoltenberg et al., 1994).

Psychotherapy Based Models: In this model, psychotherapy theories (psychoanalytic, cognitive-behavioural, systemic, etc.) are integrated into supervision processes (Harris & Brockbank, 2011). The psychodynamic supervision model focuses on the analysis of therapeutic processes and the handling of parallel processes (Zetzer et al., 2020). Cognitive and behavioural approaches focus on skill development and learning (Milne & James, 2000).

Social Role Models: In this approach, the relationship between the supervisor and the counsellor and the roles they assume are defined (Johnson, 2007). Supervisors can assume different roles such as educator or mentor. The aim in this model is to provide support appropriate to the needs of the counsellor (Davys & Beddoe, 2020).

Group Supervision Models: Group supervision involves sessions in which more than one

counsellor is present together and led by a supervisor. This format encourages participants to receive feedback from each other and promotes collective learning (Gilbert & Evans, 2000).

Reflective Learning Approaches: In this model, supervision is seen as a reflective practice; therapists engage in reflective dialogues while evaluating their own practice. Analysing and making sense of experiences is at the forefront (Scaife, 2014).

Systems Approaches: System approaches focus on examining dynamic relationships in which many factors interact. In this model developed with Holloway's system, supervision relationships and contextual factors are taken into consideration (Holloway, 2014).

Each of these models offers different strategies and methods to ensure that supervision achieves its purpose. A combination of these models is often used according to the needs of practitioners.

Measuring Supervision

Supervision plays a critical role in fostering the professional development of practitioners in psychological counseling and therapy while safeguarding client well-being (Scaife, 2013). Measuring the competencies of both supervisors and supervisees is essential for ensuring effective supervision experiences. The competence of supervisors is evaluated based on their training in relevant fields, accreditation from recognized programs, and sufficient experience in supervision practice, all of which significantly influence supervision quality (Ladany & Inman, 2012). Additionally, the ability of supervisors to manage the supervision process, including establishing and maintaining supervision contracts, is a crucial aspect of their competence. (Barnett & Molzon, 2014).

The adequacy of supervision areas is assessed through tools such as standardized supervision scales, like the Effective Supervisor Feedback Scale developed by Meydan et al., (2024), which measures the effectiveness of supervision using Likert-type ratings.

Feedback mechanisms also play an integral role, as they provide valuable insights for both supervisors and supervisees to identify strengths and areas for improvement. Qualitative research methods, including interviews and focus groups, offer a deeper understanding of the supervision process by highlighting participants' lived experiences (Saab et al., 2021). To measure these competencies comprehensively, quantitative methods, such as statistical analyses of survey and scale data, are complemented by qualitative approaches, which provide context-rich insights (DeCato, 2002). Collectively, these processes ensure the professional development of counselors, improve the quality of supervision practices, and uphold the ethical responsibility of protecting client well-being.

Methods Used in the Supervision Process

Supervision is a vital process that enhances the professional development of therapists in psychological counseling and therapy, equipping them with the skills and knowledge needed to address ethical issues effectively (Vasquez, 1992). A range of methods is employed during supervision to facilitate this development. Case presentations enable therapists to share and evaluate their practical

experiences, with supervisors providing constructive feedback to refine their practices (Davys & Beddoe 2020). Observation allows supervisors to assess therapists' styles and techniques during sessions, offering direct and actionable feedback (Kazemi et al., 2024). Role-playing serves as an experiential tool where therapists practice intervention strategies in simulated scenarios, fostering skill enhancement (Shea & Barney, 2015).

Feedback is a cornerstone of the supervision process, guiding therapists by highlighting strengths and areas for improvement. Theoretical training offers therapists insights into new theories, techniques, and ethical practices, contributing to their intellectual growth (Ivey et al., 2011). Group supervision encourages collaborative learning, providing a platform for sharing experiences and gaining diverse perspectives. Reflective dialogues with supervisors help therapists understand their own practices and foster both personal and professional growth(Orchowski et al., 2010). Lastly, self-evaluation empowers therapists to critically assess their work, promoting ethical awareness and resilience (Rawatlal, 2023).

An essential component of supervision is feedback, which plays a critical role in shaping therapists' practices and improving client outcomes. Feedback can take several forms. Immediate feedback, provided during or shortly after a session, allows for real-time evaluation of practices, while delayed feedback, based on session recordings or transcripts, facilitates detailed analysis (North, 2013).

Formative feedback focuses on continuous skill development, whereas summarizing feedback evaluates overall performance at specific intervals. Effective feedback adheres to several principles: it is clear and specific, balances positive reinforcement with constructive critique, emphasizes behaviors rather than personal traits, and is framed as actionable suggestions (Grant, 2023). Various tools and techniques enhance the feedback process. Reviewing session recordings or transcripts provides concrete insights, while structured assessment forms offer systematic evaluations (Arthur & Gfroerer, 2002). Experiential methods, such as role-playing and metaphor usage, make feedback more engaging and impactful (Smith, 2009). Together, these approaches ensure that feedback not only supports therapists' professional growth but also enhances the quality of services provided to clients. By integrating these diverse supervision and feedback methods, the process becomes a robust mechanism for fostering ethical, skilled, and reflective practitioners (Lambert et al., 2001).

Differences Between Online and Face-to-Face Supervision Practices

Supervision is a fundamental process for fostering the professional development of psychological counselors and therapists. This process can be conducted in two primary formats—online and face-to-face—each with distinct characteristics, advantages, and limitations (Stokes, 2023).

Interaction and Communication: Face-to-face supervision allows for direct personal interaction, enabling the observation of body language, tone of voice, and other non-verbal cues that strengthen the emotional connection between supervisor and supervisee (Borders, 2014). In contrast, online supervision relies on digital tools such as video conferencing, where some non-verbal communication

elements may be lost (Cataldo et al., 2023). However, online formats can supplement verbal interactions with written communication and screen-sharing capabilities, providing alternative ways to convey information (Stokes, 2023).

Access and Flexibility: Face-to-face supervision requires both parties to be physically present in the same location, which can pose challenges for professionals in rural or remote areas (Borders, 2014). Conversely, online supervision eliminates geographical constraints, allowing participants to engage in the process from any location, thus offering greater flexibility and accessibility (Cataldo et al., 2023)

Technical Challenges: Face-to-face supervision avoids technical issues and benefits from the immediacy of physical presence (Borders, 2014). In contrast, online supervision can be disrupted by problems such as internet connectivity issues or technical malfunctions, potentially interrupting the flow of the supervision process and creating distractions (Stokes, 2023).

Confidentiality and Security: Face-to-face supervision provides a controlled environment where confidentiality concerns are minimal, given the direct interaction between participants (Bengtsen & Jensen 2015). In online supervision, however, confidentiality and data security may be compromised if the digital platforms used are not adequately protected. Ensuring the security of personal data is a critical consideration in online practices (Deane et al., 2015).

Effectiveness: Research findings on the comparative effectiveness of online and face-to-face supervision are mixed. Some studies suggest that online supervision can be equally or even more effective due to its flexibility and accessibility (Bender & Werries, 2022; Rowen et al., 2022; Watters & Northey, 2020). while others emphasize the superior depth and relational bond achieved through face-to-face interactions (Beinart & Clohessy, 2017; Borders, 2014). The relative effectiveness of each format often depends on the specific needs and preferences of the practitioners involved.

In conclusion, both online and face-to-face supervision methods have unique strengths and limitations. Practitioners should consider factors such as accessibility, communication preferences, technical infrastructure, and security concerns when choosing the most suitable format. While technological advancements have expanded the reach and feasibility of online supervision, the irreplaceable value of in-person interaction in fostering emotional connections and nuanced communication should not be underestimated. Table 1 gives a comparison of both formats (Beinart & Clohessy, 2017; Bender & Werries, 2022; Bengtsen & Jensen 2015; Borders, 2014; Cataldo et al., 2023; Deane et al., 2015; Rowen et al., 2022; Stokes, 2023; Watters & Northey, 2020).

Table 1. *Comparison of Online and Face-to-Face Supervision Practices*

Aspect	Face-to-Face Supervision	Online Supervision
Interaction and Communication	Direct interaction with access to non-verbal cues like body language and tone, fostering emotional connection.	Relies on video conferencing, with limited non-verbal communication. Can use written communication and screen-sharing.
Access and Flexibility	Geographically limited; requires physical presence.	Eliminates geographical constraints, offering greater flexibility.
Technical Challenges	No technical disruptions; immediate physical presence.	Subject to internet and technical issues that may disrupt the process.
Confidentiality and Security	Provides a secure environment with fewer confidentiality concerns.	Potential risks with data security on digital platforms; requires careful handling of personal information.
Effectiveness	Strengthens relational bonds and provides in-depth interaction.	Flexible and accessible, but effectiveness may vary based on individual needs.

Conclusion

Supervision in counseling stands as a cornerstone of professional practice, rooted in a rich historical tradition that has evolved to meet the dynamic needs of the field. From its origins as a structured approach to training and oversight, supervision has expanded its functions to encompass professional development, ethical accountability, and the enhancement of client outcomes. By offering a platform for reflection, skill-building, and guidance, supervision not only supports the personal and professional growth of counselors but also ensures the delivery of competent and ethical services. The effects of effective supervision are profound, fostering resilience, confidence, and the ability to navigate complex clinical scenarios. Measuring supervision through qualitative and quantitative methods further enhances its effectiveness by identifying strengths and areas for improvement, ensuring that it remains a robust and adaptive process.

In today's rapidly changing landscape, the format of supervision—whether online or face-to-face—has become a critical consideration. While online supervision offers unmatched flexibility and accessibility, face-to-face interactions continue to provide irreplaceable depth and relational connection. Both formats have unique advantages, and their integration into practice depends on individual preferences, logistical factors, and technological infrastructure.

In conclusion, the supervision process is an indispensable element of counseling that bridges historical practices with contemporary needs. By adapting its methods to diverse contexts and embracing innovation without compromising the relational core of its practice, supervision continues to serve as a vital mechanism for professional excellence and the advancement of the counseling profession.

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Education of Gifted Pupils in Türkiye

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Introduction

Sustainable quality education activities should be carried out for the efficient use of human capital in nations. Gifted students, when their potential is considered, emerge as some of the most valuable components of human capital. Considering that gifted individuals will be at the forefront of leaders, scientists and artistic activities in their societies, it is clear that if they are not supported and cannot reveal their potential, they will not be able to contribute to the society in which they live, and this situation will have a destructive effect. One of the skills that individuals should have in the twenty-first century is higher order thinking skills including creative thinking, critical thinking and problem solving. These skills increase individuals' problem-solving abilities, their capacity to produce innovative and original ideas, and also contribute to their personal and professional development. It is thought that the use of higher-order thinking skills in education will affect the future success of gifted students and may increase the contribution expected to be made to their countries on the road to independence. More than one discipline should work together, unusual perspectives should be included, thoughts should be questioned, and new thoughts should be opened. The basic condition for achieving this goal and ensuring permanence is qualified education. The idea that it will help the country to use its resources more efficiently and help the country to become technologically, economically, politically and militarily stronger shows the strategic importance of the education of gifted individuals. Today, different strategies such as grouping, enrichment, acceleration, mentoring are used in the education of gifted students. Different strategies aim to improve students' academic skills as well as their higher order thinking skills.

Education of gifted pupils

From the past to the present, the definitions of gifted individuals have changed from conservative and restrictive approaches to more liberal and flexible definitions. In other words, today, the concept of giftedness is beyond being defined only by numerical criteria. Gifted individuals differ from their peers in terms of their learning styles and comprehension abilities. For this reason, it is necessary to differentiate the education of gifted individuals who are considered to have different educational needs. When education is differentiated according to the characteristics of students, all students can develop and learn (Bildiren, 2016; Sak, 2013). The most lasting impact of the Marland Report (1972), which was published after three years of data collection, testimony and interviews with a wide range of stakeholders including researchers, educators, administrators, policy makers and legislators, is the first federal definition of gifted children. In the 50 years since the report's

publication, no other report has been published with broad public acceptance that specifically addresses gifted students. However, the direction in which the field of gifted education will evolve in the near future is still uncertain. For this reason, there is no agreed definition among experts (Jolly & Robins, 2022).

While the search for consensus continues, gifted children often have clearly visible characteristics that distinguish them from the average of their classmates. They need special attention and support from school environments because their educational needs are different from their peers (Vouglanis & Driga, 2023). Strategies such as differentiated instruction, enhanced learning standards, teacher development programmes and specialised training programmes for talent development contribute positively to the educational success of gifted students (NAGC, 2019). The differentiated instruction approach applied by teachers for gifted students is used to foster their talents by considering their interests and socio-emotional development. Schools that function for average students must make changes in the educational experiences they offer in order to unlock the potential of gifted students. Gifted students need enriched and challenging activities, differentiated lesson plans and programmes, active learning processes, learning environments with adequate physical infrastructure and legal regulations (Davis et al., 2013).

Education of gifted pupils in Turkiye

In Turkey, gifted students receive support education at Science and Art Centre (SAC) affiliated to the Ministry of National Education. These centres were established in 1995 in order to enable children to develop their potential in the best way possible. It is important to know that these centres are not a school, and that students receive additional education in these institutions for the purpose of support education after continuing their formal education in the schools where they are enrolled. In order to gain the right to enrol in SAC, students must be identified as 'Gifted'. The identification process is initiated for primary school 1st, 2nd and 3rd grade students nominated by their teachers/ schools. Students are nominated from the fields of 'General Mental Ability', 'Music' and 'Visual Arts'. Each student can be nominated for at most two talent areas (Ministry of National Education, 2023). Although identification can be made by Guidance Research Centres in pre-school or other grades, there is no identification process for admission to Science and Arts Centres. For the specified grade levels, the commission established in the schools, with the nomination of the class teacher, determines the candidates, not exceeding 20% of the total quota. The limited quota leads to various disadvantages. This situation leads to the deprivation of the right to be recognised for gifted students who are not nominated among heterogeneously distributed classes. One of the important problems in the identification process is that classroom teachers do not have sufficient knowledge about the general characteristics of gifted students. Due to the frequent confusion between bright students and gifted students, the desired efficiency cannot be obtained in the nomination process. At the same time, families also put pressure on teachers to nominate their own children for inclusion in the identification process, which leads to problems.

Identification Process

Individuals nominated for the selection of students for SACs, which are established to support the development of gifted children, are subjected to the "Group Screening Application", also known as the "Tablet PC Application". In this screening application, students who exceed the threshold determined at the grade level are subjected to individual assessment according to the field of talent they are candidates for. 'Individual assessment' is carried out with a separate appointment system for each of the talent areas related to general mental ability, music and visual arts. Students nominated in the field of general mental ability are subjected to an intelligence (WISC or ASIS) test by experts. In the visual arts talent area, students are asked questions to reveal their visual creativity and to make original visual works, and they are asked to draw accordingly. In the field of music talent, applications are carried out in the areas of musical hearing, musical memory and musical awareness in accordance with their grade levels. Children who are successful in individual assessment are entitled to enrol in Science and Art Centre (Ministry of National Education, 2023).

Education in SAC's

According to the SAC Directive (2019), a gifted individual is defined as 'an individual who learns faster than his/her peers, is ahead in creativity, art, leadership capacity, has special academic talent, can understand abstract ideas, likes to act independently in his/her fields of interest and performs at a high level'. It can be said that this definition is quite comprehensive among other definitions of gifted students. However, when the identification process is analysed, it is seen that there are deficiencies in areas of giftedness such as creativity, leadership and sports, but the definition is important in terms of showing the vision of the country. It gives hope that the education to be offered to gifted individuals in the future can be more comprehensive.

Today, the number of SACs is close to 400 in Turkey and there is at least one SAC in each province (Figure 1). Considering the population density and the need, the number of centres in the provinces may vary. As seen in Figure 2, approximately 105 thousand students receive support education in these institutions (Ministry of National Education, 2023).

Figure 1. *Change in the Number of SACs Over the Years*
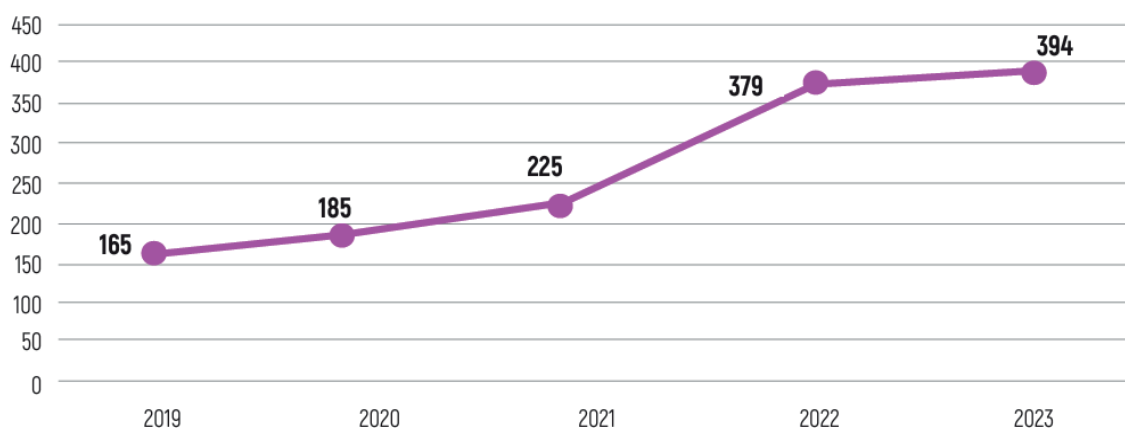
Figure 2 *Change in the Number of Students Benefiting from SAC Over the Years*
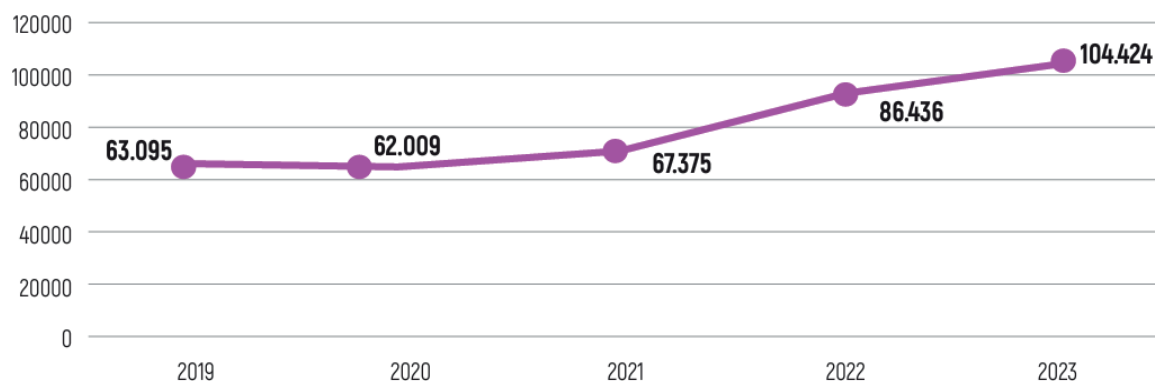
Diagnosed gifted children who are entitled to enrol as a result of individual evaluation go to the most appropriate SAC in the cities where they live and make their registrations. These centres are state-funded, and students do not have to pay any fees during the education process. Every student who successfully completes the identification process in Turkey has the right to benefit equally from the education and opportunities provided in SACs. Students are categorised according to the talent areas they are accepted as a result of individual assessment. The number of students selected from Music and Visual Arts talent areas is considerably lower than the number of students selected from 'General Mental Ability'. As shown in Figure 3, students selected from General Mental Ability constitute 85% of the total number of students selected.

Figure 3. *Distribution of SAC's-Registered Students by Talent Types*
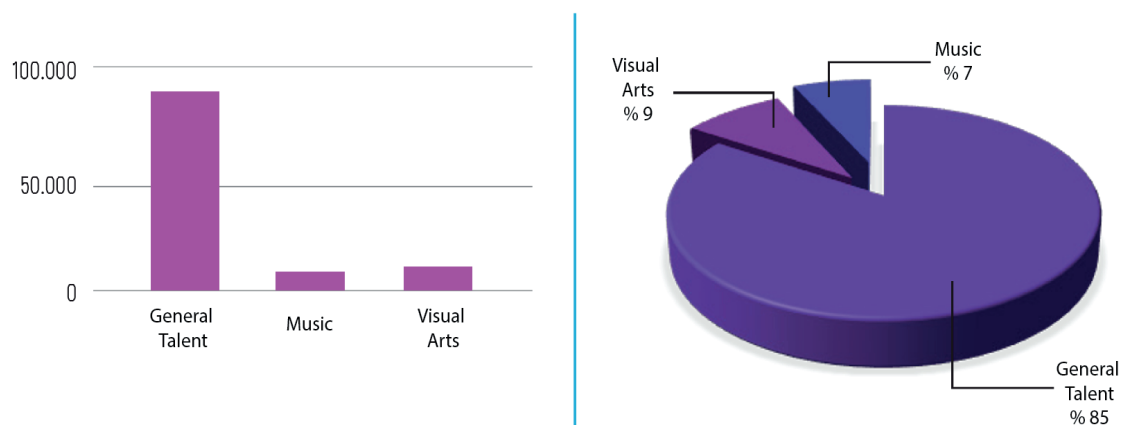
Education and training activities to be carried out in SAC are planned to be on weekdays and / or weekends outside the hours when the student receives formal education. Each lesson/activity/ workshop is planned and implemented for 40 minutes. The duration of unexcused absenteeism in an education and training year at SAC cannot exceed 30% of the training period. An absenteeism warning is sent to the student whose absenteeism reaches 20%. Students who exceed the absenteeism limit without an excuse are deregistered at the end of the term. At the end of each programme, the status of the students attending the programme is evaluated in the SAC teachers' board. Students who cannot benefit from the programme they are attending and who are decided by a majority of

votes that there is no benefit in continuing the programme are dismissed from SAC. This decision is notified to the student's parents.

A 5-stage programme is implemented for students enrolled in SACs (Ministry of National Education, 2019). The programmes are given below under headings.

Adaptation programme

It is a short-term training programme organised for gifted students who are newly enrolled in SAC, aiming to introduce the mission, vision and core values of the institution and to enable them to get to know teachers, students and programmes. Activities that contribute to personal development and encourage scientific thinking are prepared and implemented for students enrolled in the orientation programme. The adaptation programme is planned for an average of 40 lesson hours and a total of 2 months. Students who complete the adaptation programme and are selected for general mental ability are admitted to the 'Support Education Programme', which is a higher programme. Students selected in visual arts and music are placed in the 'Special Talents Development Programme'.

Support education programme (SEP)

Students selected general mental ability who have completed the adaptation programme start the support education programme as the second stage. In this programme, students continue their education with activities aimed at developing their basic skills in connection with all disciplines. Within the programme, it is aimed to provide skills such as cooperation, scientific research, higher order thinking skills, technology literacy and social responsibility. The support education programme is implemented for at least 2 academic years, including the adaptation programme, for students enrolled in the 2nd and 3rd grades, and at least 1 academic year for students enrolled in the 4th grade. Students who complete the support education programme are directed to the 'Individual Talents Awareness Programme'.

Individual talents awareness programme (IAP)

The main aim of this programme is to identify the areas in which students can carry out in-depth studies in areas where they are talented and have potential, taking into account their interests and curiosity. With the programme, activities are designed and implemented in order to enable students to realise attitudes and skills specific to different fields and disciplines. At this stage, teachers determine the students for whom they will take responsibility. At the end of this programme, which lasts for two academic years, students are directed to the areas of the 'Special Talents Development Programme' as a result of the multidimensional evaluation made by the board of teachers for each child individually.

Image 1: *Sample of SAC Classroom*

Image taken from the 2023-Activity Report of the General Directorate of Special Education and Guidance Services of the Ministry of National Education.

Special talents development programme (STDP)

Talent groups (General Mental Ability, Music and Visual Arts), which were separated after the adaptation programme, come together under the same roof again at this stage, but continue to specialise in their own fields. In the fourth stage, the special talent development programme, intensive activity-based studies are carried out on a scientific and artistic axis for the special talent areas to which students are directed by taking into account their interests and curiosities. The aim of the programme is to enable students to acquire advanced knowledge, skills and behaviours in line with their potential. Studies are carried out to enable them to produce ideas and products, especially at the synthesis stage. In the fields of Visual Arts and Music, studies are carried out to provide students within the programme with competence in the field. In-depth artistic activities are included after this stage. For this reason, the STDP programme continues for 2 years for student groups with general mental ability and for other fields for 5-7 academic years according to the grade level at which they are enrolled in SACs.

Project production and management programme

The Project Production and Management Programme, which is the last stage for students in SACs, is a training programme carried out individually or in groups in line with the student's wishes, interests and curiosities. In the programme, project preparation and implementation trainings related to the field in which the student is thought to have talent are also provided. Students participating in the programme are obliged to prepare at least one project in each academic year. Students are guided by their counsellor teachers during the project preparation process. The prepared project is evaluated in front of the jury. For the projects deemed appropriate, the patent application is made

by the ministry on behalf of the student.

Students who complete the above programmes are given a 'Programme Completion Certificate' for each stage.

Selection of Teacher

Teachers who will work in SACs are determined in accordance with the guidelines published by the Ministry of National Education for each year. According to the Guide for Selection and Appointment of Teachers for Science and Art Centres (2024), the newly appointed teachers must have served at least 3 years in public educational institutions. Eligible candidates are placed in the vacancies announced in the guideline as a result of the scoring calculated by taking into account the evaluation criteria and oral interview.

Among the evaluation criteria is the "education" received by the candidate teacher. According to this criterion, if the teacher has a master's degree or a doctorate, he/she gains additional points at different levels. Certificates of achievement or awards received by the candidate teacher during his/her service period, projects he/she has participated in at national and international level, scientific studies, artistic activities, in-service trainings, congresses, foreign language and having an expert/head teacher career level also provide points to the teacher in different categories. In the oral interview, the candidate teacher's communication skills, reasoning power, openness to scientific developments, merit, ability to represent in front of the public, up-to-date knowledge, creativity and willingness are evaluated.

Score ranking is taken into account in the evaluation criteria used in appointments. Among the teachers who fulfil the score requirement, 3 times as many teachers as the announced quota are invited for an oral interview. The final score is calculated by combining 60% of the score obtained from the evaluation criteria and 40% of the oral interview score. Teachers are placed in the vacant quotas according to the total score (Ministry of National Education, 2024).

In addition to the placed teachers, the Ministry of National Education organises field-based in-service trainings, seminars or courses every academic year in order to increase the efficiency and quality of the teachers currently working in SAC. These programmes are held at least once a year (Ministry of National Education, 2019).

Conclusion

Countries want to increase their national income by processing the mines they have. As well as the mines, which are called underground treasures, gifted individuals, which are considered as above-ground treasures, have a strategic importance. Developed countries owe their success to the quality of projects and products produced by gifted individuals. That is why the education of gifted students is of essential for every country. Turkey has mobilised its means to reach gifted individuals in the last 30 years. With the increase in the budget allocated to education in the last 20 years, the number of gifted individuals and the number of SACs where these individuals receive education has increased. The main objectives of SACs include meeting the needs of students with

leadership spirit and creativity, encouraging learning by doing and experiencing, providing project-based learning and supporting the social and emotional development of students with a holistic approach. In SACs, a project-based, interdisciplinary education programme is implemented by differentiating through enrichment and acceleration in accordance with the abilities of students in order to realise original products, projects and productions (Ministry of National Education, 2019). It is necessary to give importance to quality as well as quantity. For this reason, it is necessary to provide training for teachers who will deal with gifted students and to provide support for interdisciplinary cooperation and teamwork. There is a need to develop environments that will enhance the experiences of gifted people.

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Enviromental Education and Sustainable Development

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One of the most significant problems threatening humanity is environmental issues. The environment encompasses the physical, biological, social, cultural, and economic conditions in which living beings interact and sustain their relationships (Ministry of Environment and Urbanization, 2018). Factors contributing to environmental problems include deforestation, global warming, acid rain, unplanned urbanization, agricultural fires, erosion, pollution, and the depletion of the ozone layer (Sönmez & Yerlikaya, 2017). Wars and human activities driven by personal interests also exacerbate these issues (Atasoy & Ertürk, 2008). While humans are the primary cause of environmental problems, they are also key to their resolution. Individuals with environmental awareness play a crucial role in addressing these challenges (Erten, 2004; Escobar, 1995).

Environmental issues represent a global problem affecting all humanity, regardless of sociocultural status, race, belief, or language. Although the term "environmental issues" was first defined in 1960 (Gelmez, 2015), it became more prominent over time in industrialized countries. Various meetings were held and agreements were signed to address these problems. At the Stockholm Conference in Sweden in 1972, efforts were made to establish a framework for addressing environmental and economic issues. The conference, attended by 113 countries, led to the establishment of the United Nations Environment Programme (UNEP) to foster partnerships encouraging societies to care for the environment without risking future generations.

The establishment of UNEP marked the beginning of sustainability, emphasizing the conservation of resources for future generations. Among the most notable agreements is the 1977 Tbilisi Declaration, a milestone in environmental education for sustainable development. The declaration outlined environmental education as a solution to environmental issues, detailing its goals and content (Dere and Çinikaya, 2023). The goals of environmental education, as articulated in the Tbilisi Declaration, include raising awareness of the relationships between economic, political, and social conditions in rural and urban life, empowering individuals with the knowledge and skills needed to address environmental problems and fostering positive behaviors toward the environment. In 1987, the concept of sustainable development was introduced in the Brundtland Report (Our Common Future) (Dere & Çinikaya, 2023). Most recently, the 2022 Paris Agreement, signed by 194 countries, established an action plan to reduce greenhouse gas emissions. Sustainable development consists of three key components: environmental, economic, and social. The importance

of environmental sustainability was also emphasized in the Göteborg Report prepared by the European Council (Büyükuslu, 2021; Erişkin, 2019).

Figure 1. *Chronological Order of Envirementol Policies*
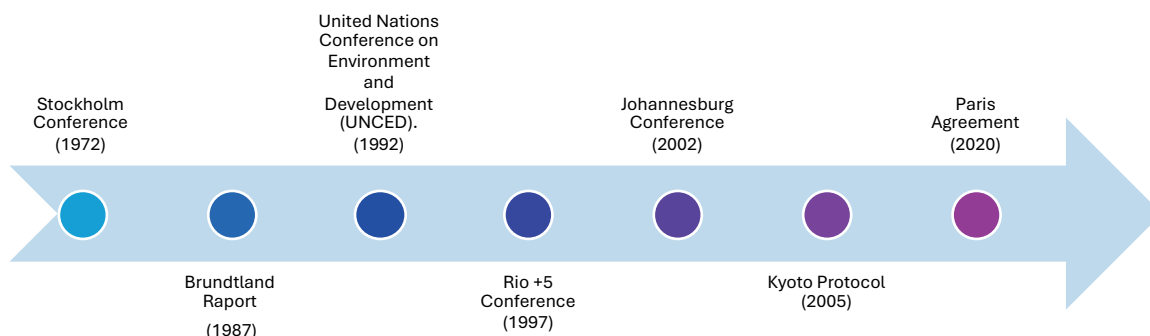
In line with the goals of sustainable development, environmental education aims to enable students to understand environmental issues, develop solutions, and comprehend the complexity and functioning of environmental systems (Davis, 1998). Sustainable environmental education targets the preservation and responsible use of natural resources to ensure the well-being of future generations. By shifting from an anthropocentric (human-centered) perspective to an ecocentric (environment-centered) approach, the pressure humans exert on nature can be reduced (Gülersoy, 2022). Indeed, as Pandey (2008) argues, it is crucial for individuals to receive quality environmental education in today's world, where environmental issues significantly impact human life.

The United Nations announced the 2030 Global Sustainable Development Goals to address these challenges (UNESCO, 2018). Environmental education must align with these goals to enhance awareness of environmental issues. Additionally, the principles of environmental education outlined in the Tbilisi Declaration are crucial for success. These principles emphasize:

- Environmental education should begin in early childhood and continue at all levels throughout life.
- Pupils should acquire knowledge about environmental conditions across all geographic regions and evaluate environmental problems from regional, national, and international perspectives.
- The importance of cooperation at regional, national, and international levels should be highlighted in taking measures and finding solutions to environmental problems.
- Cultural and historical contexts should be considered in addressing existing and potential environmental conditions in education.
- Environmental education should allow students to take on roles, make decisions, and accept the consequences of their decisions through well-planned learning experiences.
- It should help students identify the root causes of environmental problems.
- Environmental education should provide environmental awareness, sensitivity, knowledge, and problem-solving skills, taking into account the developmental stages and ages of students. Special attention should be given to fostering environmental awareness in younger age groups.

- Environmental education should offer hands-on learning opportunities. Teachers should design diverse and practical learning environments for their pupils.
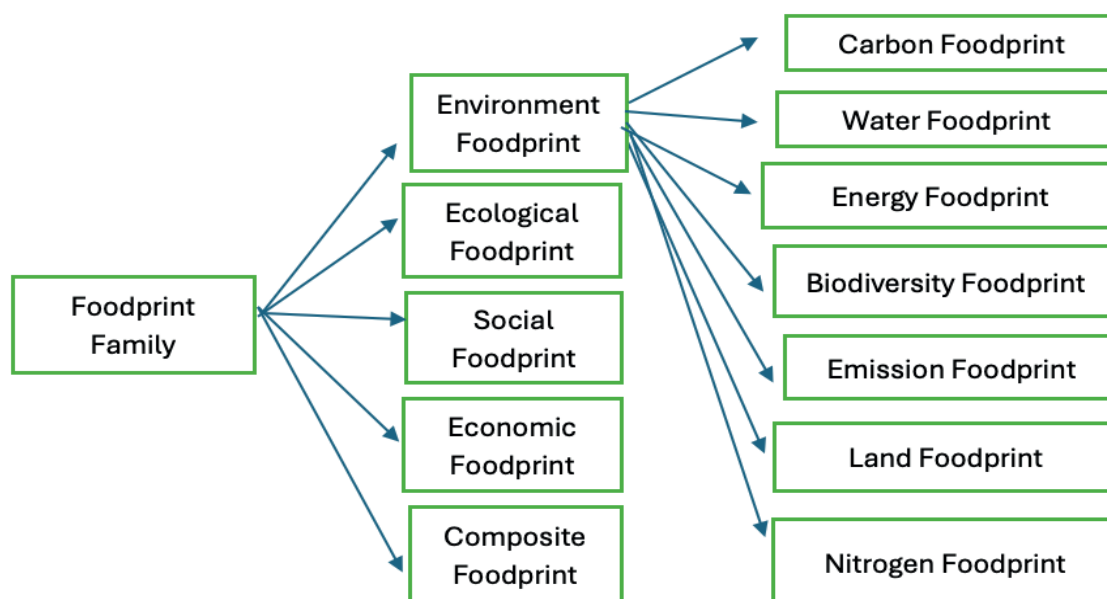
Sustainable environmental education plays a vital role in addressing global environmental issues by fostering a shift in perspective and promoting the permanence of environmentally conscious behaviors (Forinash, Perkins, & Whitten, 2021). Roth (1992) underscores that environmental education must be experiential to achieve its objectives. In this context, sustainable environmental education is implemented differently across countries. Some, like Austria and Denmark adopt an interdisciplinary approach, while others, such as Finland and Belgium, include it as a distinct subject in their curricula (Özata Yücel & Özkan, 2013). Glasser and Hirsh (2016) highlight the importance of facilitating societal transformation toward sustainability and enhancing individual capacities to achieve sustainability goals. Introducing environmental education early in childhood is particularly critical.

A review of the literature on sustainability education reveals a wide range of studies on its scope and practices (Tanrıverdi, 2009). Various perspectives exist regarding the learning outcomes of education intended to be delivered from early childhood to higher education levels. Analysis of sustainable environmental education programs indicates that topics such as ecological footprint, carbon footprint, water footprint, and biodiversity are emphasized in these curricula.

Ecological Footprint

The ecological footprint family is considered one of the most critical pillars of sustainability. Footprints are used to evaluate ecological systems. Each footprint, which reveals human pressure and impacts on the environment, is calculated individually, and the system is assessed holistically (Hoekstra & Mekonnen, 2014). The ecological footprint family is illustrated in Figure 2.

Figure 2. *Foodprint Family (Hoekstra ve Mokennan, 2014)*

The footprint family included in environmental education is interconnected and mutually influential. In sustainable science education, terms such as ecological footprint, water footprint, carbon footprint, and biodiversity are emphasized in curricula from primary to college education.

The ecological footprint is defined as the amount of water and land required to mitigate the negative impacts arising during the production and consumption of a product (WWF, 2012). This concept quantifies the consumption of natural resources by calculating the biologically productive area needed (Akıllı et al., 2008). The calculations provide a basis for determining measures to ensure the sustainability of existing resources.

Image 1. *Ecological Foodprint*

According to the Living Planet Report (2012), the components of the ecological footprint are categorized into six groups: carbon, grazing land, forests, fishing grounds, cropland, and built-up land. The ecological footprint was first calculated by Wackernagel and Rees in 1997, and a second calculation method was introduced by WWF (2012) based on the ecological footprint hypothesis.

> Ecological foodprint: Consumption × Production Area × Population

In the ecological footprint formula, the term "consumption" represents the level of product usage, while the term "production" refers to the biologically productive area required to sustain consumption within certain limits. According to the global ecological footprint ranking published by WWF (2024), China has been identified as the country with the highest footprint. The top 10 countries in the ecological footprint ranking are presented in Table 1.

Table 1. *Ranking of Countries Ecological Foodprint*

Country	Total ecological foodprint (Global Hectares)
China	5.1 Billion Hectares
USA	2.6 Billion Hectares
India	1.5 Billion Hectares
Russia	848 Billion Hectares
Brazil	551 Billion Hectares
Japan	533 Billion Hectares
Indonesia	454 Billion Hectares
Germany	392 Billion Hectares
Mexico	315 Billion Hectares
France	312 Billion Hectares

The World Wide Fund for Nature (WWF) has identified a series of measures to be taken at the national level to reduce ecological footprints. These include: creating natural parks that support the harmonious coexistence of humans and animals with nature, ensuring the continuity of biodiversity, eliminating practices that put pressure on species and hinder sustainability, ending production and consumption practices that harm humans, plants, and animals implementing decisions related to biodiversity and conservation areas, creating and protecting habitats for animals and emphasizing environmental education to ensure the balanced coexistence of living organisms.

Carbon Footprint

The carbon footprint, the largest component of the ecological footprint, represents the impact of human activities on nature to meet our needs (Lynas, 2009). Due to the significant contribution of carbon dioxide emissions among greenhouse gases, it is a primary driver of global warming. For this reason, greenhouse gases are often converted to carbon dioxide equivalents in calculations (Wiedmann & Minx, 2008). The carbon footprint encompasses various parameters, ranging from transportation to food consumption (Kitzes et al., 2008). These parameters also reveal insights into the sociocultural and socioeconomic levels of countries, as consumption habits and lifestyles are reflected in their carbon footprints (Jones & Kammen, 2011). Excessive consumption behaviors disrupt the ecological balance and increase pressure on nature. However, fostering environmental awareness from an early age and understanding the impact of human activities can help individuals reduce their carbon footprints.

Water Footprint

In addition to the carbon footprint, another significant term in environmental education is water awareness. While the amount of accessible freshwater on Earth is limited, global population growth is making access to water increasingly difficult (Aslanova, 2015). According to data from the Turkish Statistical Institute (TUIK), Turkey's population will reach 100 million by 2030. Therefore, it is crucial to pay attention to the efficient use of water. Although Turkey has not experienced below-average rainfall for many years, there are issues with drinking water reserves

(DSI, 2023). In this context, a national water mobilization project has been implemented. The goal of the water mobilization project is to ensure the sustainability of water resources. Sustainable water management is based on the implementation of water efficiency technologies and the alteration of human behaviors to ensure proper water management (Ministry of Agriculture and Forestry, 2024). According to the Finnish Environment Institute (2019), virtual water use should also be considered in ensuring water sustainability. Virtual water refers to the amount of water consumed throughout the life cycle of a product, from the use of raw materials to the processing of waste (WWF, 2024). For example, 10,850 liters of virtual water are used to produce a single pair of jeans. Therefore, the calculation of water footprints and raising awareness about unconscious water usage is essential. The water footprint not only provides information about water capacity but also offers insights into where and how water is used (Hoekstra & Mekonnen, 2012). The components of the water footprint are shown below.

Figure 3. *Components of the Water Foodprint (Hoekstra ve Mekonnen, 2012)*
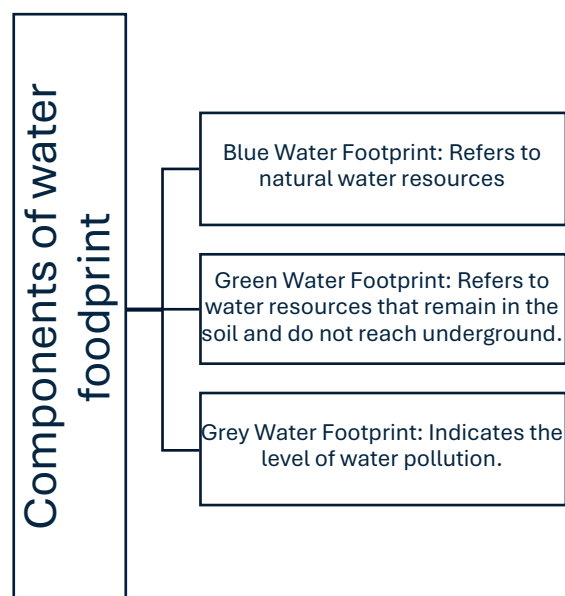
Taking measures to reduce the water footprint will reduce the likelihood of water shortages in the future. In this context, various precautions have been proposed in the literature. These include:

- Encouraging individuals to calculate their water footprint to raise water awareness.

- Implementing water conservation measures.

- Including water footprint education in environmental training to reduce behaviors that increase water usage.

- Reviewing energy consumption and water-saving criteria when purchasing products.

- Collaborating with non-governmental organizations (NGOs) to focus on reducing the water footprint.

- Limiting agricultural land by using modern irrigation methods.

- Choosing crops with lower water footprints.

- Utilizing water purification systems.

- Paying attention to the use of agricultural chemicals.

Energy Footprint

The energy sector and energy policies are intertwined with many other sectors. Managing food and agricultural resources requires a significant amount of energy (Food and Agriculture Organization, 2015). Achieving food production with optimal energy consumption has led to a shift towards renewable energy sources to meet heating needs. Since the environmental footprint occurs during the supply phase of chains such as water, food, and energy, it is important to take necessary precautions to reduce the high environmental impact (Reynolds et al., 2016).

Emission Footprint

The concept of sustainable development refers to reaching the level of developed countries by making improvements in socio-cultural and economic factors for a country. One of the key indicators of a country's development level is its emission footprint. 46% of the emission footprint consists of carbon footprint (Lenzen et al., 2018). Therefore, limiting consumption activities that cause carbon emissions will reduce the greenhouse gas emission rate. Individual vehicle use, fossil fuel consumption, and industrial activities lead to an increase in greenhouse gas emissions. In line with sustainable development goals, increasing environmental awareness, limiting fossil fuel use, and imposing carbon taxes on organizations that emit carbon will contribute to reducing the emission footprint.

Land Footprint

Half of the habitable land on Earth is used for agriculture. For some food crops, less land is used, while for others a lot of land area is used. Land use for food crops determines the land footprint. The land footprint varies from farmer to farmer. However, there may be differences in land footprints depending on where and how food products are produced. The balance of agricultural land is considered important to protect rural life and ecological balance (Ritcie and Roser, 2021).

Nitrogen Footprint

The nitrogen footprint refers to the reactive nitrogen that results from human activities. In particular, the consumption of fossil fuels leads to an increase in nitrogen levels (Cucek et al., 2012). To ensure a sustainable environment, necessary measures should be taken to reduce the nitrogen footprint and a shift towards clean energy sources is recommended.

Biodiversity

Biodiversity is a key term in environmental sustainability education. Biodiversity, which is one of the most important components of an ecosystem, refers to the variety of life and living forms (Yörek, 2006), and is defined as diversity within species, between species, and in ecosystems (Şenel, 2015). According to Granek et al. (2001), it encompasses the diversity of life on Earth, from genes

to species and ecosystems. Biodiversity is examined at three different levels: genetic, species, and ecosystem diversity (Perktaş, 2012). Genetic diversity refers to the survival of endangered species, and populations with high genetic diversity tend to have higher resistance to diseases (Çiftçi, 2019). Species diversity is the difference between species within an ecosystem (Levine et al., 2000). Species diversity is also expressed as genetic diversity (Gündüz, 2011). The ecosystem in which an organism can continue its natural life provides global differentiation (Granek et al., 2001).

The preservation of biodiversity is necessary for sustainable development and creates strategic power for countries in both economic and ecological contexts (Kekillioğlu, 2023). The greatest factor negatively affecting biodiversity is humans (Çelik, 2010). The decline in biodiversity can threaten agriculture and fishing, causing economic losses (Costanza et al., 1997), lead to the increase of infectious microorganisms, creating risks to public health (Keesing et al., 2010), impact carbon storage capacity by the loss of various species, resulting in higher greenhouse gas levels and cause food insecurity. Therefore, it is important to implement measures to protect biodiversity. Some of the measures suggested in the literature for protecting biodiversity include the establishment of gene banks for endangered species and the protection of endangered species. Environmental education should continue, and public awareness should be raised. Necessary sanctions should be applied against illegal hunting (Kekillioğlu, 2023).

Image 2. *Biodiversity Visualisation*

In summary, the conscious use of existing resources and the reduction of all kinds of human activities that put pressure on the natural environment affect ecosystems, biodiversity, ecological footprint and thus sustainability. In this context, raising environmental awareness of individuals will contribute to producing solutions to environmental problems, which are among the biggest problems of today. As a matter of fact, the Global Foodprint Network (GFN), which explains the limit of measuring the resources of the world by humans, announced Turkey's limit exceeding day as 28 July as of 2024. Therefore, it is very important to raise environmental awareness in the context of our country. Environmental education plays a role in the formation of environmental awareness, the development of positive attitudes of individuals towards the environment and the permanence of the developed behaviours. In line with the sustainable approach, environmental education is expected to affect the quality of life of future generations. Environmental education should be included in the teaching process in the context of sustainable development goals, which

are emphasised among the aims of the new curricula, and it is important to carry out practices in terms of creating environmental awareness in students.

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The Effect Of Summer Vacation On Multiple Intelligence Types And Science Learning Processes

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The Effect of Summer Vacation on Students

Summer vacation is a period eagerly awaited by students, especially due to the hot weather conditions. Summer holiday durations vary from country to country. In Northern European countries, holiday durations are generally limited to 4-6 weeks and are planned over certain periods throughout the year (Cooper, 2003). In contrast, in Mediterranean countries such as Türkiye, Greece, Italy and Spain, summer vacation lasts from mid-June to mid-September (Kerry and Davies, 1998). The origin of the long summer vacation practice dates back to the period when agriculture was the dominant economic activity. In agricultural societies, summer vacations were long because children had to join the workforce during harvest periods (Gierczyk and Hornby, 2023). Therefore, the duration and timing of summer vacation in the education system have been affected by historical and economic factors and have continued to the present day. These different vacation durations and practices can have various effects on education policies and student success. While shorter and more frequent vacations are thought to help students maintain continuity in learning, long vacations are thought to provide students with the opportunity to rest and engage in different activities.

The learning losses that students experience during the summer vacation can negatively affect their academic success and make it difficult to achieve their educational goals (Hastings and LaBriola, 2023). These learning losses that occur during the summer period are considered an important factor in the emergence of academic achievement differences among students (Allington and McGill-Franzen, 2003). Research shows that these losses during the summer vacation play a critical role in the emergence of achievement differences among students. In this context, educational research has long been interested in the effects of summer vacation on learning, and this situation has an important place in the education policies of countries with the aim of reducing academic achievement differences (Coley et al., 2020). Learning losses during the summer period have become a subject of increasing interest in national and international education research (Coley et al., 2020; Arı, 2005; Stewart et al., 2018). These studies are important in understanding how the length of the summer vacation and students' learning opportunities are affected during this period. Various studies show that students experience significant learning losses in their academic success during the summer vacation period. A study conducted in Turkey by Arı (2005) revealed

that fourth-grade primary school students experienced significant learning losses in Mathematics and Turkish during the summer vacation period. Similarly, it was stated that third-grade primary school students experienced significant learning losses in Mathematics and Life Sciences during the summer vacation period (Şen, 2009). However, no clear findings were presented regarding the loss in the Turkish course. The striking point in these studies is that the losses in the mathematics course are more pronounced than in the other courses examined. Studies conducted in countries other than Turkey have also revealed that students experience learning losses during the long summer vacation period. Studies conducted on primary school students have shown that learning loss varies according to the grade level. For example, it has been stated that there are significant losses in writing skills in second and third-grade primary school students and in mathematics skills in fourth and fifth-grade students (Atteberry and McEachin, 2021). The studies mentioned support the hypothesis that long summer vacations can negatively affect students' academic success. It has also been emphasized that learning loss does not vary by gender and race, but the amount of learning loss increases as the grade level increases (Cooper et al., 1996).

Intelligence

The concept of intelligence has been defined in various ways by many researchers since the time it was first investigated. This diversity stems from the fact that intelligence is a multidimensional and dynamic capacity (Tura and Akbaşlı, 2021). Intelligence can be defined as a process that includes reasoning, planning, problem solving, abstract thinking, comprehending complex thoughts, and learning quickly from experience (Wechsler, 1955). Studies aimed at determining the brain and its working structure in order to achieve meaningful and permanent learning have become an important area of interest. First, intelligence tests were put on the agenda to determine the extent to which the brain can use its functions (Bozbey-Esmeroğlu, 2016). Although researchers assumed that individuals' reaction times were related to their intelligence levels, the results often did not match this assumption. Initially, intelligence was considered as a single whole, but later it was realized that there was a non-one-to-one relationship between intelligence and creativity (Köroğlu and Yeşildere, 2004). Creative individuals are generally among those with good or even superior intelligence levels, but it shows that not everyone at this level is creative. This finding has led scientists to consider the possibility that there may be different types of intelligence (Oleron and Güngören, 1992). The common characteristics of the intelligence tests that scientists use to express intelligence quantitatively include fast thinking and being based on mathematical and verbal skills. However, there are also areas such as art, music or sports where success can be achieved without these skills. This situation shows that intelligence is not limited to mathematical and verbal abilities, but spreads over a wider spectrum. In this context, it is understood that intelligence is a multidimensional and dynamic capacity, and therefore also includes talents and skills in different areas. Research in the fields of education and psychology continues its studies to understand the different types of intelligence in individuals and how these types can be developed. This multidimensional structure shows that intelligence is a dynamic and developing capacity rather than a static characteristic. Therefore, intelligence research uses different perspectives and methodologies to understand and

improve the cognitive abilities of individuals.

Intelligence and Development Process

Intelligence refers to an individual's ability to learn, solve problems, think abstractly, and adapt to the environment (Şimşek, 2015). The development of intelligence is shaped by genetic factors and environmental influences (Horn, 1968). The period when intellectual development is most rapid in human life is early childhood. During this process, synaptic density increases and basic cognitive skills develop rapidly in the brain (Balkış Baymur, 2017).

• Ages 2-5: This is a critical period for children's brain development. Language, motor skills and basic cognitive abilities develop rapidly during this period. Environmental stimuli (e.g. play, social interaction) positively affect this development.

• Ages 6-12: Learning accelerates during this period. Children transition to abstract thinking and reach the capacity to solve more complex problems. Education is very effective during this period.

• Ages 12-18: This is the period when brain maturation continues and the prefrontal cortex (the region responsible for planning, decision-making and control skills) continues to develop. Although intelligence development slows down, learning continues.

Intelligence is shaped by environmental interactions and the level of brain usage, as well as genetic infrastructure (İnci, 2021). Active use of the brain and rich environmental experiences are critical to maximizing intelligence potential. For this reason, it is of great importance to support individuals with learning opportunities from an early age and to adopt lifestyle habits that protect brain health.

General Framework of Intelligence Theories

Studies on intelligence have led to the development of various theories to understand and measure this phenomenon. Although theories of intelligence adopt different approaches, they are generally interconnected and complementary.

Single Factor Theory: General Intelligence Factor

The Single Factor Theory is an approach that considers intelligence as a general factor affecting all cognitive abilities of an individual. The basic premise of this theory is that the performance of an individual in different types of cognitive tasks can be explained by a single general intelligence factor (g factor) (Baymur, 2017). This approach, first proposed by Charles Spearman, assumes a common mechanism underlying all cognitive processes (Spearman, 1904). In this theory, intelligence is defined as a general and abstract ability (Lövdén et al., 2020). Different psychologists have explained this general ability in various ways. Terman defines intelligence as the ability to think abstractly. Davis sees intelligence as the ability to solve problems and use existing knowledge effectively. Stern associates intelligence with the ability to adapt to new situations and respond to

events using the power of thinking (Yıldız, 2021). It assumes that there is a positive relationship between different cognitive skills in all individuals. For example, if a person is successful in verbal expression skills, it is predicted that he/she will also be successful in mathematical problem solving. Therefore, this theory offers a limited perspective in understanding the nature of intelligence and can be seen as inadequate, especially when compared to alternative models such as Gardner's theory of multiple intelligences and Sternberg's theory of trichotomous intelligences.

Spearman's Two-Factor Theory

The Dual Factor Theory, developed by Charles Spearman in 1904, explains intelligence as a structure consisting of two basic components. These components are general ability (g) and special abilities (s). This theory argues that both general and specific factors are effective together when evaluating an individual's cognitive abilities (Akt., Yıldız, 2020). According to Spearman, general ability is the individual's basic cognitive capacity that is effective in all mental processes. This factor forms the basis of mental skills such as abstract thinking, problem solving and understanding complex relationships. These abilities vary from individual to individual and only affect success in a certain area (Şahin, 2015). For example, a person may be successful in mathematics but not have the same level of musical ability. Spearman's Dual Factor Theory is an important approach that emphasizes that intelligence is a combination of both general and special abilities. Instead of reducing intelligence to a single factor, this theory has the potential to explain different components of individual performance. However, today more holistic approaches (for example, multiple intelligences or triads of intelligences) are more widely used to understand the nature of intelligence. Nevertheless, the dual-agent theory remains one of the fundamental building blocks of cognitive psychology.

Sternberg's Triarchic Theory of Intelligence

Robert J. Sternberg (1996) argued that intelligence is too complex to be reduced to a single dimension and developed the three-stage intelligence theory. This theory analyzes the cognitive processes of the individual and addresses intelligence in three basic components. These are divided into analytical intelligence, creative intelligence and practical intelligence. Sternberg argued that this approach offers a more comprehensive understanding of intelligence than traditional IQ tests and predicts individuals' success in work and school more accurately (Mert, 2015). He suggested that there are mental abilities that are necessary for an individual to adapt to their environment, to choose and reshape the environment. According to Sternberg, intelligence includes the individual's ability to perceive problems, create strategies for solution and implement solutions. These processes enable the individual to respond effectively to the challenges they encounter in both the abstract and practical world. He also emphasizes that these processes may differ depending on the cultural context and environmental conditions.

Thurstone's Group Factor Theory

Louis Thurstone argued that intelligence is not a single general ability and consists of more than one mental factor. According to him, different problems require different mental powers (Thorndike, 1920). From this perspective, Thurstone suggested that intelligence consists of a series of independent cognitive factors. Although he initially determined 12 factors that constitute the basic structure of intelligence, he later reduced this number to seven basic abilities (Baymur, 2017). These abilities are as follows; Verbal Comprehension: The ability to understand the meanings of words and interpret linguistic expressions. For example, reading and making sense of a text quickly and accurately. Verbal Fluency: The ability to remember and use words quickly and effectively. Numerical Ability: The capacity to perform mathematical operations quickly and accurately. For example, doing mental calculations or solving mathematical problems. Spatial Visualization: The ability to mentally visualize and manipulate spatial objects. For example, it is used in map reading, architectural design, or understanding three-dimensional shapes. Memory: The capacity to remember information for a short or long time. This ability is decisive in the learning and storage processes. Perceptual Speed: The ability to perceive and interpret visual and auditory information quickly. For example, quickly finding the wrong item in a list. Inductive Reasoning: The ability to derive general rules from data and apply these rules to new situations. For example, finding the correct answer by noticing a pattern in a series of problems.

According to Thorndike, evaluating these three dimensions together is necessary to understand the individual's intelligence capacity more comprehensively. Focusing on only one of these dimensions provides an incomplete approach to the assessment of intelligence (Uçar & Aliyev, 2017).

Multiple Intelligence Theory

The theory of multiple intelligences, which explains learning, which is a paradigm in the field of education, with mental, sensory, motor and visual intelligence, was developed by Howard Gardner. In the development process of the theory, data obtained from studies conducted on geniuses, gifted individuals, patients with brain damage, autistic people, normal children and adults, experts in various fields and people from different cultures were examined. As a result of these studies, Gardner proposed in his book "Frames of Mind: The Theory of Multiple Intelligences", which he published in 1986, that intelligence had seven aspects instead of the two aspects accepted at that time. According to Gardner, contrary to the traditional understanding of intelligence, intelligence is not limited to mathematical and linguistic achievements. Individuals who show themselves in areas such as sports, music, dance, painting, communication and self-awareness should also be considered intelligent (Ayaydın, 2017). This theory aims to reveal the interests, talents and potential of individuals and argues that each individual has different types of intelligence. The theory of multiple intelligences advocates supporting intelligence and intelligence development with individualized approaches in accordance with student-centered education. According to this theory, it is emphasized that each student has different types of intelligence and that education should be planned with methods that address these differences. The aim is to provide equal opportunities in

education by taking into account the talents and interests of each individual and to maximize the potential of students (Soylu, 2011). According to this theory, the types of intelligence are;

1. Verbal Intelligence

Verbal intelligence includes the ability to use language. Individuals with this intelligence have knowledge about the qualities of language. These individuals have the ability to persuade, present information and communicate effectively in different languages. Verbal intelligence; learns best by listening, speaking and seeing words (Berkant and Ekici, 2007). It is also an area where language skills are affected in the event of brain damage (Bornstein and Gardner, 1986).

2. Mathematical Intelligence

Also called logical-mathematical intelligence, this type of intelligence includes logical reasoning, numerical analysis, abstract thinking and problem solving skills. Individuals with mathematical intelligence can easily grasp cause-effect relationships. They can understand abstract concepts and organize complex thought structures (Bornstein and Gardner, 1986). Mathematical intelligence is a type of intelligence that includes individuals' logical, numerical and abstract thinking skills. This type of intelligence also affects the individual's daily life skills that require problem solving and analytical thinking (Karabay et al., 2011). With education and support, this type of intelligence can be strengthened even more and contribute to the individual's lifelong success.

3. Visual Intelligence

Also known as visual-spatial intelligence, it refers to an individual's ability to perceive, interpret and manipulate images, pictures, spaces and three-dimensional thought structures. This type of intelligence includes the ability of an individual to effectively process, organize and produce solutions to visual information (Gardner, 2011). Visual intelligence is a skill that allows an individual to effectively understand and use visual and spatial information. This type of intelligence, which is effective in a wide range from daily life to professional success, strengthens individuals' aesthetic and analytical thinking skills. It is thought that supporting education in the early stages is important in revealing individuals' creative and problem-solving potential.

4. Musical Intelligence

This type of intelligence refers to the individual's capacity to perceive, distinguish, remember and produce sounds, rhythms, tones and other elements in the musical structure. Individuals with musical intelligence usually easily understand and express complex relationships in the musical structure (Gardner, 2011). Musical intelligence is an important type of intelligence that develops the individual's musical sensitivity and creativity and supports learning processes. It is important for the individual to be noticed and supported in childhood so that they can develop a successful career in the field of music and contribute to other areas of learning through music (Yavuz, 2009).

5. Bodily Intelligence

It refers to the ability of an individual to use their own body effectively and manipulate physical objects. This type of intelligence is important both in terms of the individual's ability to control their body and to interact with the physical world around them. This type of intelligence is particularly associated with movement, coordination, balance, agility and tactile skills (Gardner, 2011). It is also an important type of intelligence that allows an individual to interact with the world by using their body as a tool and to successfully perform complex physical tasks. This type of intelligence is a fundamental element that increases creativity, learning and success in daily life, both at the individual and social level (Bümen, 2005). For this reason, it is important to support and develop the potential of individuals with this type of intelligence in education and life.

6. Social Intelligence

A type of intelligence that includes the ability of an individual to communicate effectively in social environments, manage human relations, understand others and cooperate (Gardner, 2000). This type of intelligence plays an important role in both individual and social contexts. Social intelligence is a skill set that allows an individual to take part in social life effectively and harmoniously. It increases the quality of both individual and social relationships thanks to its components such as communication, empathy and cooperation (Yavuz, 2009). This type of intelligence can be developed through learning and experience and can contribute to the success of the individual in all areas of life.

7. Intrapersonal Intelligence

Intrapersonal intelligence or personal intelligence is defined as the ability of an individual to focus on their inner world, understand themselves, identify and manage their emotions (Gardner, 2000). Intrapersonal intelligence is a powerful mechanism that guides an individual's life. It supports the individual in achieving their life goals by increasing their self-confidence and establishing more harmonious relationships with their social environment through skills such as emotional awareness, self-management and personal development (Yavuz, 2009).

8. Naturalist Intelligence

It refers to the individual's interaction with nature and the environment and their sensitivity in this area (Gardner, 2000). Naturalist intelligence includes the ability to recognize and classify living things in nature and understand the relationships between them. It also includes the curiosity and observation skills of individuals towards the environment and the awareness of protecting nature. It is the awareness and understanding capacity that an individual develops towards nature and the environment (Yavuz, 2009). Curiosity towards understanding the natural world, the ability to classify and sensitivity to the environment are the basic elements of this intelligence.

Variables Predicting Students' Summer Learning Loss: Family Education Level and Socio-Economic Factors

One of the critical factors affecting students' learning processes and academic success is the education level of the family. Learning losses observed in students, especially during the summer vacation period, are closely related to this factor. The education level of the family is one of the basic elements that shape learning motivation, academic performance and long-term continuity in education life throughout the school period (Erdoğan and Güvendir, 2019).

Summer vacations are a period that offers students the opportunity to rest and have fun, but also carries the risk of losing knowledge and skills. In educational research, the primary factor affecting learning loss is the level of education of families (Aslanargun et al., 2016). While a high level of education in families increases the likelihood that children will continue their learning processes during the summer vacation, a low level of education has a triggering effect on learning loss. In this context, it is important to analyze the effect of the level of education of families on students' academic success. Studies show that the level of education of mothers, in particular, is a critical factor in children's school attendance and dropout rates (Yam and Kumcağız, 2021). It has been observed that children in families with high levels of education attend school more regularly and have higher academic success (Sezgin et al., 2020). On the other hand, it has been stated that the mothers of the vast majority of students who drop out of school have low levels of education. Low levels of education in mothers can negatively affect children's motivation for education and limit educational support mechanisms within the family. The level of education of families is generally related to socioeconomic status. Families with low levels of education may not be able to provide resources for their children's education or develop awareness about this issue (Aslanargun et al., 2016). This situation is a risk factor that increases learning loss, especially during summer vacations. Families with high levels of education tend to direct their children to various programs and activities to ensure that they continue their learning activities during the summer vacation. According to the research of Slates et al. (2012), students who live with both parents, whose mothers are at least twenty years old when they are born and who are the first child of the family experience less learning loss during the summer vacation. This finding shows that stability within the family and the maturity level of the parent depending on their age contribute positively to the child's learning processes. It is thought that being the first child in particular may be related to parents generally allocating more attention and resources.

Summer Vacation Durations and Learning Loss

In some European countries, the duration of summer vacations is quite short compared to Turkey. Countries such as Germany, the Netherlands and the UK keep their summer vacations under seven weeks, while other European countries apply around ten weeks of summer vacation. Although the number of days of education and training in these countries is similar, shorter vacations are taken three or four times a year. In Turkey, the summer vacation lasts an average of 3 months and there is no other vacation period other than the semester break (Auld et al., 2019). This planning

in Turkey can be considered as a factor that can increase learning losses.

Professional musicians or athletes observe that their performance declines when they take a long break. Similarly, students have difficulty regaining their pre-holiday academic performance after long summer vacations (Baş, 2023). Observations and research in the field of education reveal that teachers notice declines in their students' learning levels during long vacations (Boulay and Fairchild, 2002). The uninterrupted nature of the educational process allows students to learn in the most effective way. Long summer vacations disrupt this continuity and cause the information learned to be forgotten. When students return to school in the fall, they have to spend a considerable amount of time and educational materials to compensate for this loss. This situation leads to a disruption of the educational rhythm and a significant loss of productivity at the beginning of the academic year. This problem becomes more pronounced and serious, especially for students with special educational needs. These students face greater difficulties in compensating for learning loss after long vacations, which can cause them to fall behind in education (Cooper, 2003). Summer vacation learning losses occur as a result of the interaction of individual and environmental factors. In addition to the family's socio-economic status and level of education, the family's structural characteristics and the child's mental competence are important variables that determine the severity of these losses. It is important for education policies to develop supportive programs during the summer period by taking these factors into account in order to minimize learning losses. Therefore, it is of great importance for education policies and calendars to be organized in a way that protects students' learning continuity in terms of academic success and equality in education.

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Philosophy for Children and Thinking Skills

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Definition of Philosophy for Children

Philosophy begins with thought and Dewey defined thought as "everything that passes through our minds". Although thinking is handled in different ways in the sub-definitions of this general statement, Dewey emphasized reflective/deep thinking, which is a thinking process "based on the causes and consequences of our beliefs", as a process of questioning/interpretation in his work "How Do We Think? (Dewey, 2022).

When we look at the history of educational philosophy before Dewey's expression of thinking and teaching/developing thinking skills in education in this way, many philosophers have expressed and practiced ways of developing thinking in different ways. Socrates, Plato, Aristotle, Rousseau, Pestalozzi, Herbart and Froebel asked many questions about education and sought ways to develop thinking in different ways (Noddings, 2017). Vygotsky's thoughts emphasizing the impact of language on children and learning and Bruner's emphasis on culture as the concept that shapes the human mind and human life have also encouraged educational research based on speech and communication (Lyle, 2008).

As for Philosophy for Children, although the sources generally state that Lipman introduced this concept, as stated, the ways of teaching/developing thinking skills in education have gradually changed since the existence of thought. Lipman's (1976) concept of 'reasoning' refers to effective thinking processes, while Worley's (2023) concept of 'hypothetical thinking' refers to making sense of what a situation that does not actually exist means for us.

Based on these definitions of thinking, we can state that the way of thinking that forms the basis of the philosophy program for children is a process of making sense and forming a habit of thinking, and teaching thinking skills.

Today, the rapid pace of social and technological developments and the unpredictability of what information will be needed require children to be open-minded about their future and to anticipate what information they will need. Early childhood is the most suitable period for the child to develop his/her thinking skills, when his/her mind spontaneously turns to philosophy, his/her curiosity has not yet diminished, he/she asks questions and begins to recognize life. (Fisher, 2022; Matthews, 2000).

Children may have the same cognitive processes as an adult in the process of exploring thinking, but they try to make new sense of the world differently from adults. Adults generally accompany

children's thinking processes as a guide (Fisher, 2022). Therefore, philosophy for children is seen as a process of learning to think (critical thinking, creative thinking, etc.) that provides this guidance within a community, and there is a constant effort to make sense of life due to the transition from concrete thought to abstract thought in early childhood. Children should be given the opportunity to discover themselves as thinking and feeling individuals (Daniel & Auriac, 2011; Fisher, 2022).

The Main Aims of Philosophy for Children

The question of when children begin to reason philosophically can be considered a critical question for the practice of philosophy for children. Considering that not all people engage in philosophical activity, children's asking the question 'why' can be considered as a start (Lipman, Sharp & Oscanyan, 2010). Everyone defines the meaning of life within their own meaning-making system. The most important issue for humanity and indeed for the individual is to develop his/her innate potential in the best way possible. In order to find the meaning of life, the family and society in which the individual lives must see this as a top priority (Cüceloğlu, 2020). Philosophy for Children aims to draw attention to classification, part-whole connections and cause-consequence connections in this life and aims for children to use them in their lives. The fact that philosophy accepts both areas of intelligence as valid and important, unlike science, which emphasizes the cause-consequence connections and art, which emphasizes the part-whole connections, makes it a very important part of educational practices (Lipman et al., 2010).

In this early childhood period, when children start to get acquainted with school, the school is generally the one that reflects the values of the time, does not challenge them and does not propose alternatives, because this is far from the school imposing its will on the child and the community and makes parents feel safer. For children, it's a different story, where education is the worrying part of school and coming together with peers is what makes school attractive. (Lipman, 2003).

Another worrying element for children is talking about life situations or problems that are challenging them. But it is also in childhood that the basic behavioural patterns of our lives are largely formed. Therefore, environments where their peers are present and where problems similar to their own are discussed may be more interesting for them and they may find answers to their own questions (Adler, 2022; Lipman et al., 2010). In addition, such environments encourage the child to learn and be aware with his/her friends and encourage the child to think and question more independently. It has an important role in the development of teacher-student and student-student dialogues (Topping & Trickey, 2007).

Thinking Skills Development and Philosophy for Children

There is a belief that only senses, motor skills and memory develop during infancy. It is as if thinking skills are thought to develop as the child grows older, especially during adolescence. However, the thinking that is active in experiences during infancy and childhood can become an advanced thinking system as it is used and developed. (Dewey, 2022). In the past, it was thought that philosophical thinking could not be encouraged among primary school children, and that

philosophical discussions could take place from middle school onwards. However, the distinctive features of philosophical thinking are already stated to be the ability to understand the value of ideas, logical arguments, conceptual systems and to see part-whole connections in different ways, regardless of age (Lipman & Sharp, 1978).

Philosophy for Children is based on the premise that critical thinking and dialogue are necessary conditions for transforming children into democratic, free citizens, and when discussing the definitions of relevant practices, the 'community of inquiry' practices involving critical thinking and dialogue are mentioned (Vansieleghem, 2005). Through this questioning, children develop a perspective on the world, justify and interpret their own beliefs, values and experiences, and understand where their assumptions come from (Lipman & Sharp, 1978).

According to Fisher (2001) Philosophy for Children provides opportunities for development in many areas; information processing skills, inquiry skills, reasoning skills, creative thinking skills and evaluation skills are among the most important.

There are different views interpreting the relationship between morality and education. These views include those who argue that all education has a moral dimension, those who insist that under no circumstances should educators try to introduce morality into the classroom (because in their view this is inevitably nothing more than indoctrination), and those who argue that quality education system must include a component of moral education. Many of the Philosophy for Children practices include parts that involve ethical questioning. The teacher implementing these practices thinks that teaching children to reason logically, including about moral issues, will help to solve human problems (Lipman et al., 2010).

The Role of School and Teacher in Philosophy for Children Practices

There are few meaning-making opportunities for children to participate in classrooms, and most teachers lack many skills to facilitate effective, learning-based discussion that involves all students (Lyle, 2008). The relationship between teacher and student is a complex, multi-factorial one that also affects factors such as communication and learning. The teacher should know both the individual characteristics and habits of his/her students and the conditions that affect them. In other words, the teacher's task is not only to follow the mentally designed steps, but also to think about how the teacher himself/herself, his/her peers, the school atmosphere and the school administration affect the student (Dewey, 2022).

In Philosophy for Children practices, the teacher encourages students to think more independently through open-ended Socratic questioning, to create a community of inquiry, and to foster strong teacher-student and student-student communication (Topping & Trickey, 2007).

Haynes (2008) identified nine steps for the process of philosophical enquiry in the classroom;

- Reaching agreement on rules of interaction, starting with a relaxation exercise,

- Sharing a stimulus (story, object, picture, etc.) to prompt enquiry,

- Giving time for reflection and thought on the stimulus,

- The pupils think and ask interesting, surprising and puzzling questions,

- Linking questions, making links between the questions,

- Choosing a question to begin an enquiry,

- Encouragement to develop thoughts about the question, to follow each other's thinking and to open up ways of questioning by the session leader,

- Create a visual to summarize and record the discussion and process creation,

- Summarizing and reflecting the process.

One of the most important points in Philosophy for Children practices is how the teacher, the guide, manages the process. Because one of the situations that will determine the quality of the practices is the competence of the teachers on this issue.

In this study, Çayır (2023) asked teachers about the problems they experienced in the process of Philosophy for Children, the source of these problems and their suggestions for solutions to these problems. As a result of the research, 5 main problem areas were identified. She stated that these problem areas are related to teachers, children, perspectives on Philosophy for Children, facilities, course and school programs.

Looking at the general results of the research;

Teachers' **:**

- Difficulties in deepening the discussion and asking questions,

- Directing children to the answer they think is right, problems with not being impartial,

- Not having enough experience in philosophy with children, which affects their ability to conduct discussions,

- Choice of stimulant,

related problems come to the forefront.

According to other results;

- Children's egocentric approaches, their underdeveloped listening skills, and their difficulty in understanding abstract concepts make philosophical discussion difficult.

- Teachers stated that Philosophy for Children should be included in the curriculum as a course by the Ministry of National Education and that studies should be carried out to associate it with the curricula of other courses.

- The physical layout of the classrooms and crowded classrooms negatively affected the

process of philosophizing with children.

The Acquisitions of Philosophy for Children

For children;

During philosophical enquiries, learners are encouraged to ask their own questions and raise issues for discussion, explore and refine their ideas, views, and theories, justify their beliefs with clear reasoning, articulate and defend their perspectives to others, actively listen to and consider alternative viewpoints, and ultimately adapt their thinking in response to sound reasons and evidence (Fisher, 2001). Therefore, the most emphasized skills that Philosophy for Children is thought to develop are information processing, questioning, reasoning, creative thinking and evaluation skills (Fisher, 2001). Lipman also emphasized that it would develop reasoning, concept formation, judgment and questioning skills (Lipman, 1995).

Unlike the high-order thinking skills, we have mentioned about the achievements of "Philosophy for Children", the area related to values and morality, which is not usually mentioned much, can be expressed. Lipman (2011) mentions the concept of caring thinking, which describes sensitivity to values, the ability to understand what is important in the application of theory to practice, and the cognitive role of emotions. The concept of caring thinking includes understanding the difficulties and beauties encountered in life, understanding the part-whole relationship, considering the context of issues, noticing details, and making decisions about moral situations (Lipman, 2011). Philosophy for Children can make children think better and different about everything throughout their lives (Matthews ,2004).

For teachers and parents;

Teachers and parents rediscover situations and events through children's ideas and gain a new perspective on the world through child-directed discussions. In addition, adults talking with children about deep and important issues is one of the best ways to improve intergenerational relationships (Matthews, 2004)

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Section 2;
Educational Technologies

The Eye-Tracking Method in Mathematics Education

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Introduction

Eye tracking is a process to determine and evaluate where, how long, and how often an individual looks at any given moment, and in what order the eye moves from one direction to another (Duchowski, 2017; Holmqvist et al., 2011; Majaranta & Bulling, 2014; Schall & Bergstrom, 2014). Therefore, the eye-tracking (ET) method offers eye movement data about the areas of the screen or object that people pay attention to, the elements they ignore, and the things they are uncomfortable with (Russell, 2005). The data assist in the interpretation of the individual's interests, visual attention, and perception of the scene (Duchowski, 2017; Horsley, 2014). Therefore, the ET method is used to reveal the cognitive process resulting from the relationship between eye fixations and visual attention (Sennersten, 2008). In other words, the ET method is used to collect data in the context of conducting experimental studies on human perception, cognition, and behavior (Abrahamson et al., 2017; Shayan et al., 2017).

The ET method reflects the cognitive process instantaneously in the various tasks under consideration (Just & Carpenter, 1976; Rayner, 1998). By observing and interpreting eye movements, information is obtained about cognitive operations and processes in the brain (Biedert et al., 2009). There are basically two types of eye movements: fixation and saccade (Salvucci & Goldberg, 2000; Winke et al., 2013). Fixation movement generally refers to situations in which the eye is fixed and immobile in one area (Schall & Bergstorm, 2014; Sharif & Maletic, 2010). The fixation movement provides information about where and for how long the individual looks, that is, where they direct their attention (Rayner, 1998). The fixation duration and fixation count values, derived from this information, can be used to measure attention to the displayed stimulus (Glaholt & Reingold, 2011; Wang et al., 2014b). Fixation duration and fixation count are the most commonly used ET data to assess cognitive processing (Just & Carpenter, 1976). The saccade movement of the eye can be defined as the rapid movement of the eye from one fixation to another in order to help the individual to integrate the whole scene they are looking at (Schall & Bergstrom, 2014).

The data obtained through eye tracking offers researchers information about the processes underlying participants' perception, attention, memory, or reasoning abilities (Maurage et al., 2021). For example, a student's eye fixations can be used to get an idea of the amount of time and attention the student needs to process the given stimulus (Eckstein et al., 2017). Moreover, the accuracy and latency of students' saccadic eye movements can provide information about their cognitive control capacity (Munoz & Everling, 2004) and the count of saccades can provide information about their reasoning ability (Thibaut & French, 2016).

The ET method is founded on the eye-mind theory. According to this theory, the eyes are windows to the mind. That is, eye movements form a highly informative component of people's observable behavior, which allows us to infer what people are thinking based on their actions (Salvucci, 2000). When and where the eyes move in a complex task is the most important factor in the cognitive process during the task (Just & Carpenter, 1980; Rayner et al., 2012). Thanks to the eye-mind theory, it becomes possible to make inferences about a person's intellectual and cognitive process by evaluating the data on where a person looks, where they focus while looking, or how often they look.

The utilization of the ET method offers various benefits to researchers. First of all, it allows the decomposition of tasks into phases with different processing times (Just & Carpenter, 1976). At the same time, the ET systems used in today's technology automatically and in real-time track where the individual is looking on the computer screen (Oyekoya & Stentiford, 2004). These features provide a great advantage to the researcher. In this way, the researcher has an idea about the cognitive process during the execution of the task without being exposed to participant interpretation. In addition, the fact that ET data support other types of data is a great opportunity for researchers (Karn et al., 1999).

Eye trackers

Historically, it can be said that the first techniques used to obtain eye movements were those involving direct physical contact with the cornea. These techniques are potentially harmful methods as they may damage the cornea of the participant (e.g. Javal, 1878). For this reason, in later studies (e.g. Javal, 1879), the eye movements of the participants were analyzed with the help of mirrors. The number of blinks was obtained by means of microphones placed in the eye. However, this method records eye movements subjectively and is limited by the accuracy and memory of the observer (Dodge, 1906). Therefore, in the following periods, new methods were needed to record eye movements objectively and without interfering with the participant.

Many techniques have been tried and developed in the historical process. As of the 2000s, ET devices (eye trackers) have become more ergonomic and capable of faster processing. These devices are based on a method called corneal reflection (Carter & Luke, 2020). That is, they determine the points at which the participant is looking by recording pupil movements (Duchowski, 2017; Lilienthal & Schindler, 2019). Most of these modern eye trackers are video-based and are categorized into two groups: screen-based and mobile (Carter & Luke, 2020). Screen-based eye trackers are ET tools that can be mounted on desktop and laptop computers or used with devices such as tablets and phones through an apparatus (Duchowski, 2017). With these eye trackers, participants' eye movements on the stimuli presented on the screens of devices such as computers and tablets are monitored and recorded. Mobile eye trackers are portable and glasses-like devices that can be worn on the participants' heads (Duchowski, 2017). With these eye trackers, participants' eye movements are monitored and recorded during a physical activity (lecturing, performing a task, etc.). Therefore, while screen-based eye trackers restrict the movements of the participants, mobile

eye trackers offer an environment where participants can move more freely. However, it can be said that the data quality and sampling frequency of mobile eye trackers are relatively lower than screen-based eye trackers (Strohmaier et al., 2020).

Eye-tracking studies in mathematics education

Since the ET method is experimental, a laboratory environment is needed to carry out the studies in a proper way. This causes the studies to be limited to university-level students in general and to be difficult to apply to different audiences. Strohmaier et al. (2020) found that the majority of the studies conducted in mathematics education involved participants from higher education levels.

The ET method provides an idea about where and for how long students look at a stimulus (Duchowski, 2017). However, ET data do not provide information on the cause of these gazes. Therefore, it does not provide a context for researchers. For this reason, using ET data alone is difficult to interpret.

Despite these challenges, eye tracking is a powerful tool for mathematics education research (Schindler & Lilienthal, 2018). The ET method provides a way to make powerful inferences about the difficulties students face in understanding cognitive tasks covering visual, textual, graphical, and stereotypical contents (Obersteiner & Tumpek, 2016; Paskovske & Kliziene, 2024). ET, which provides insights into students' mathematical thinking and learning processes, is a valuable tool in mathematics education research (Strohmaier et al., 2020). Therefore, the use of the ET method in mathematics education research has been increasing in recent years (Paskovske & Kliziene, 2024; Schindler & Lilienthal, 2018; Strohmaier et al., 2020; Türkoğlu & Yalçınalp, 2024).

The ET method can be used in many areas of mathematics education. Some of them are as follows: arithmetic and numbers, differences between groups, geometry, math learning disability, mathematical proof, mathematical representations, problem-solving process, statistics, and strategy setting (Figure 1).

Figure 1. *Usage Areas of the ET Method in Mathematics Education*

Arithmetic and numbers: Arithmetic and numbers constitute the basis of mathematics. Therefore, many ET studies have been conducted on these subjects in mathematics education. Mental calculation (Porras et al., 2024), mathematical operations (Klein et al., 2014), number line (van't Noordende et al., 2016), fraction comparison strategies (Obersteiner & Tumpek, 2016), calculation estimation (Ganor-Stern & Weiss, 2016), and numerical cognition (Mock et al., 2016) are examples of studies conducted in the field of arithmetic and numbers.

Differences between groups: Determining the differences between groups allows for a comparative analysis of the cognitive characteristics of the groups. Many studies have been conducted to reveal the differences between certain groups when solving the same mathematical problems using eye tracking. For example, differences between eye movements on specific tasks have been examined in groups of students such as strong and weak students in mathematics (Rottman & Schipper, 2002), gifted and non-gifted students (Sajka & Rosiek, 2015), novice and expert students (Wang et al., 2014a), successful and unsuccessful problem solvers (Lin & Lin, 2014), students with high and low mental rotation ability (Roach et al., 2016), and students with and without mathematics learning difficulties (Schindler et al., 2020; van der Weijden et al., 2018). Many variables such as attention span, regions of attention, number of fixations, task completion time, etc. can be compared between groups.

Geometry: Due to the relationship between geometric thinking and visual perception, it has become an appropriate method to use the ET method in the perception and processing of geometric objects (Strohmaier et al., 2020). Therefore, many ET studies have been conducted in the field of geometry. In geometry education, ET studies are carried out on geometric proofs (Alqassab et al., 2018; Schindler et al., 2016), mental rotation tasks (Roach et al., 2016; Voyer et al., 2020),

construction of geometric objects (Lee & Wu, 2017; Shvarts, 2018), the perception of objects in the Cartesian plane (Shvarts, 2018), identification of geometric shapes (Dreneva et al., 2021; Verdine et al., 2017), geometric misconceptions (Uygun et al., 2024), pattern recognition (Baumanns et al., 2024), geometric problem solving (Schindler & Lilienthal, 2019), digital task design (Bairral & Aldon, 2024).

Math learning disability (Dyscalculia): Studies show that eye tracking has diagnostic potential for detecting mathematical difficulties (Almfjord & Hallberg, 2021). In addition to diagnostic studies on mathematics learning disabilities (van Viersen et al., 2013), ET studies are also conducted on basic number processing deficits (Moeller et al., 2009), quantity recognition-comparison (Pitta-Pantazi et al., 2024; Schindler et al., 2019), counting (Schindler et al., 2020), number line (Landerl et al., 2017; Simon & Schindler, 2022).

Mathematical proof: Understanding and reading mathematical proofs is an important activity in learning mathematics (Mejia-Ramos & Inglis, 2009). In literature, there are many studies on mathematical proofs using the ET method. How to pay attention to additional visuals while reading mathematical proofs (Beitlich et al., 2014), proof verification behavior (Inglis & Alcock, 2012), and comparison of reading behaviors in the proofreading and verification process (Panse et al., 2018) can be given as examples of studies conducted in the field of mathematical proof.

Mathematical representations: Mathematical representations are defined as structures that replace, embody, and encode mathematical ideas or relationships (Goldin, 2014). Therefore, mathematical representations have an important place in mathematics education. In teaching of mathematical concepts, it is important to carry out studies on which of the different representations of mathematical concepts is more interesting and which representation facilitates the learning of the concept, etc. In the literature, there are many studies conducted using the ET method on mathematical representations. ET studies on mathematical representations are carried out in many areas such as the ability to read different representations of the mathematical object (Andrá et al., 2015), the effect of visual representation on the understanding of symbolic representation (Atagi et al., 2016), the comparison of representations in terms of comprehensibility and applicability (Bolden et al., 2015), the comparison of the use of single and multiple representations in problem solving (Liang & She, 2021; Malone et al., 2020; Ott et al., 2018).

Problem-solving process: The tracking of students' eye movements during the process of problem-solving allows for the identification of the temporal sequence of solution steps, as well as the acquisition of information pertaining to the underlying problem-solving processes (Schindler et al., 2016). Straka et al. (2021) also state that the ET method is effective in examining students' problem-solving processes, comprehension strategies, and metacognitive abilities. The ET method reflects the cognitive process instantaneously in the various tasks under consideration (Just & Carpenter, 1976; Rayner, 1998). Therefore, it provides researchers with the advantage of uninterrupted observation of the individual's problem-solving process (Inglis & Alcock, 2012; Obersteiner & Tumpek, 2016). This method makes it possible to observe the process without

comment or intervention. In addition, it reveals students' unconscious cognitive processes during problem solving. Even if the student is not aware of these processes, the process can be read from the student's eye movements (Schindler & Lilienthal, 2019). There are many ET studies on the problem-solving process in mathematics education (For example, Lin & Lin, 2018; Mayer et al., 2023; Schindler & Lilienthal, 2019). In addition to these, there are also studies in which the teacher's gaze behaviors throughout the problem-solving activity were examined. For example, Haataja et al. (2018) examined the teacher's gaze behavior when supporting peer interaction and mathematical thinking throughout a collaborative problem-solving activity.

Statistics: The use of the ET method in statistics education studies is relatively less (Boels, 2023; Strohmaier et al., 2020). In the field of statistics education, ET studies on how statistical graphs such as histograms (Boels et al., 2024; Lyford & Boels, 2022), box plots (Abt et al., 2023) and dot plots (Boels, 2023; Schreiter & Vogel, 2024) are analyzed and interpreted. In addition, studies on Bayesian reasoning (Cohen & Staub, 2015) and misconceptions (Fleig et al., 2017) are also carried out.

Strategy setting: Eye tracking is a valuable tool for identifying strategies used in mathematical tasks (Beitlich & Obersteiner, 2015; Obersteiner & Tumpek, 2016). The ET method is particularly suitable for analyzing problem-solving scenarios involving visual strategies (Malone et al., 2020; Ott et al., 2018). In the literature, there exist many ET studies performed to determine the strategies used by students while solving mathematical problems (Kang et al., 2023; Lin & Lin, 2014; Zheng & Cook, 2012).

Recommendations for eye-tracking research

The ET method is becoming increasingly important in the field of mathematics education. Since the method requires an experimental application and is relatively new, it is recommended to pay attention to some issues. Therefore, under this heading, some suggestions that may help researchers in ET research are presented.

a) Supporting eye-tracking research with think-aloud data

The ET method, which assumes that there is a connection between an individual's visual focus and cognitive focus (Just & Carpenter, 1980), suggests that eye movements are related to the cognitive process. However, the ability to accurately associate eye movements with cognitive processes is one of the most important challenges in ET research (Strohmaier et al., 2020).

ET data do not provide context for the researcher. Interpretation of eye movements without providing context to the data may not always be correct. For example, the fixation of the participant at a point for a long time may be interpreted as the participant finding that area interesting, but it may also mean that the participant has difficulty interpreting that area. For this reason, ET data should be combined with other methods and data that provide additional information about the participants' experiences (Schindler & Lilienthal, 2019; Tobii Technology, 2009). It is generally advised that ET data be supplemented with other data collection methods, such as the think-aloud

method (Csíkos & Steklács, 2015; Elbabour et al., 2017; Elling et al., 2011) or interviews (Bolden et al., 2015).

There are two principal types of think-aloud method: concurrent think-aloud (CTA) and retrospective think-aloud (RTA) (Tobii Technology, 2009). In the CTA method, students explain their thoughts aloud at the same time while completing the task. This shows that the CTA method may change what is thought during the task; that is, it is reactive. Compared to the RTA method, the CTA method is more susceptible to reactivity (Russo et al., 1989). Since reactivity may negatively affect the validity of the studies (Russo et al., 1989), it may be recommended to use the RTA method instead of CTA in ET studies.

In the RTA protocol, the participant may not remember everything he/she thought during the task. This may lead to participants' thoughts being expressed less, incompletely, or restructured, that is, as fabricated (Elling et al., 2011; Guan et al., 2006; Russo et al., 1989). Furthermore, verbal accounts may contain a greater degree of rational judgment or strategy than the actual judgments and strategies employed by participants when undertaking the test. The participant may clarify their actions in a way that makes them appear more systematic, rational, organized, thoughtful, or coherent (Kuusela & Paul, 2000). This shows that the RTA protocol may not be accurate in this context (Russo et al., 1989).

In order to prevent the accuracy problem encountered in the RTA method and to help the participant's memory, a cued RTA method is proposed. In the cued RTA method, participants are instructed to think aloud retrospectively based on a record of observations or intermediate products in the problem-solving process and are reminded of their memories of this process (Van Gog et al., 2004). Using a supporting video or other memory cues helps to recall the information in long-term memory (Hyrskykari et al., 2008). This leads to better results as it reduces forgetting and/or fabrication of thoughts (Van Someren et al., 1994). Cued RTA methods can be diversified as video-cued, gaze graph-cued, gaze video-cued.

The problem of not remembering the thoughts correctly (accuracy problem) encountered in the RTA method is solved by using the combination of ET and think-aloud methods together (Elling et al., 2011). The use of eye movements as cues in RTA methods allows participants to produce more words and comments (Tobii Technology, 2009). Many studies also argue that adding eye cues to the think-aloud method is beneficial and provides more informative and multi-word verbal data (Ball et al., 2006; Eger et al., 2007; Hyrskykari et al., 2008; Olsen et al., 2010; Russo, 1979). In the RTA method with ET cues, participants are shown the real behavior by watching their own gaze again as a video. Since it reduces fabricated verbal expressions, it is considered as a valid and reliable method in ET research (Guan et al., 2006).

b) Spaced presentation of stimuli

The first fixation point shows where the students start to solve the task. It has an important role in determining the behavior pattern performed during the solution of a task. Therefore, determining

the first fixation point correctly is important for the reliability of the study.

A saccade is influenced by the properties of the immediately preceding fixation and saccade (Tatler & Vincent, 2008). When stimuli are presented to students in succession, the first fixation point for a stimulus may be the same as or close to the last fixation point of the previous stimulus. Therefore, the first fixation point will be affected by the previous stimulus, and reliable data will not be obtained. In order to prevent this and to correctly identify the first fixation point, it may be appropriate to show a blank page between stimuli. In this way, the student will have the opportunity to rest his/her eyes between the two stimuli, and the factor that will affect the first eye movement of the student will be eliminated.

c) Training of participants

One of the situations affecting the reliability of the ET studies is, conducting with the participants who encountered the ET method for the first time. Since novice participants who are not familiar with the ET method will try to get used to the method during the application, reliable eye recordings may not be obtained. In order to prevent this and increase the reliability of the data, it is recommended to train the participants (Elbabour et al., 2017; Elling et al., 2011). A training session can be organized for students to experience the environment that they will encounter in real practice within the scope of the research. This session can be in the form of training in which the ET method is explained, or it can be realized by the student experiencing the ET method with a different stimulus. In this session, students will gain experience on how the ET device works, how to calibrate/decalibrate, how far they should stand from the screen, and their positions. Therefore, the quality and reliability of the data obtained from ET devices can be increased.

d) Data quality

ET data quality is generally considered in terms of accuracy and sensitivity. Accuracy is defined as the systematic shift between a known target position and the gaze position reported by the eye tracker (Hessels et al., 2015). Sensitivity is defined as the ability to reliably reproduce a measurement (Nyström et al., 2013). Therefore, obtaining high-quality ET data is important for the accuracy and repeatability of the study. However, Strohmaier et al. (2020) found in their review that most of the ET studies in mathematics education do not adequately mention eye movement data quality.

An additional measure of ET data quality is data loss (Porras et al., 2024). Data loss may occur due to the student's movement, sneezing, etc., or due to the fact that the calibration is disturbed, or the environment is noisy, bright, etc. Especially when using screen-based eye trackers, it is extremely difficult to avoid data loss, given that some samples are always lost due to participants blinking or averting their gaze away from the monitor (Tobii, A. B., 2023). Therefore, it is important to report the data losses that occur in the studies.

Calibration is required to ensure the accuracy of the data. With this process, the point that the student looks at and the point detected by the device are matched. Although the calibration

process is vital for ET research, the vast majority of ET studies in mathematics education do not mention the calibration procedure (Strohmaier et al., 2020). When performing long-term tasks, performing multiple calibrations in the process increases the accuracy of the data (Carter & Luke, 2020). Therefore, it is important for ET studies that long-term tasks are performed in parts and that the calibration is renewed between each part.

e) Organization of the experimental environment

In the most general sense, the ET method records the instant attention of the individual. Thus, for ET studies to be conducted effectively, experimental environment must be optimized by removing distractions. There are many features that the laboratory environment should have during ET experiments. Distraction of the student's attention during the application has a negative effect on obtaining healthy data. For this reason, firstly, the experimental environment should be free from distracting factors such as noise, clutter, or crowds. The second factor affecting ET studies is related to lighting. A brightly lit environment makes it difficult for the eye tracker to perceive the eye reflection. Therefore, a dimly lit environment allows quality data to be obtained. Thirdly, fixing participant position is an important factor for ET studies. Participants are not allowed to change their position during the experiment in order not to disturb the calibration. For this reason, the height of the students' seats or the distance between the computer and the participant can be regulated so that the participants can sit in a comfortable position (Duchowski, 2017; Płużyczka, 2018).

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An Overview of The STEM Education Model

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Introduction

Today, knowledge is the most easily accessible reality. The acceleration of access to knowledge has changed the expectations of societies from individuals. The expectation of societies from individuals is to be able to offer creative solutions with the knowledge they have (Bağcı & Şahbaz, 2012) Today, it is more important to make knowledge useful than to have knowledge. This has increased the importance of interdisciplinary studies. The modern world approaches individuals with a holistic education approach that questions them and can transfer the knowledge they have to different fields (Şahin Alpaslan et al., 2014). Especially the developments in the field of artificial intelligence have increased the interaction of technology with other branches of science. The increasing interaction of technology with science, engineering and mathematics has increased the importance of the STEM approach. For example, when it is desired to design a drug with artificial intelligence, a mathematical infrastructure is needed for the theoretical modeling of the newly created drug, and a science and engineering infrastructure is needed for its synthesis. Technological developments and innovations in education systems increase the need for the STEM approach. There are countries that are trying to implement STEM education in order to provide students with the knowledge and skills needed in the 21st century and to cope with the challenges of the fourth industrial revolution (Bahrum et al., 2017; Brown-Martin, 2018; Sulaiman et al., 2023; Türk et al., 2018).

Success in education is defined as the display of appropriate behaviors in line with the goals of the determined program (Demirtaş & Güneş, 2002). Today, the goals of programs are generally to raise individuals with 21st century skills. When the STEM education model is successfully implemented, the cultural world of the student is enriched while achieving the determined goals, and at the same time, it develops self-efficacy such as problem solving and critical thinking (Corlu & Aydin, 2016).

Comparison of STEM education models in different countries

STEM is a term that was included in the policies of the US government in the early 90s. (Koehler et al., 2016). Since then, countries have tried to integrate the STEM education model into their education systems in order to increase their competitiveness. In particular, technological developments in China have pushed the US to seek new ways to increase its competitive power in this race. This has enabled STEM to enter education policies in the US. In the 2000s, other countries have added the STEM education model to their own policies because the STEM education model

includes features that individuals in the 21st century need to have, such as problem solving, creativity and collaboration. (Gough, 2015). Although countries have a consensus on the importance of STEM education, there are various differences in practices. In other words, countries determine their STEM education policies in line with their own needs. Accordingly, practices in STEM education vary. According to the study conducted by Arslan and Arastaman, (Arslan S. Y. & Arastaman G., 2021) STEM education in Australia is based on improving the health of the population, preserving the existence of water and food for future generations, growing the economy and increasing the power of the country. It is understood from the study of Arslan and Arastaman that the aim of STEM education for Hong Kong is to raise individuals with versatile and different skills that will increase the competitive power of the country. In the same study, it is understood that the aim of STEM education for Ireland is to raise individuals with high-quality labor force, and Canada wants to equip its citizens technologically and increase their competencies such as critical thinking and problem solving with STEM. America is the first place in the world where STEM education was introduced. In America, it is aimed to continue the vision of being a global leader with STEM education. According to the STEM education report published in Turkey in 2016 (MEB, 2016), while the aim in Russia was to develop science, engineering and medical programs with STEM, the aim in the Netherlands was to increase the number of scientists and engineers, in France to increase the interest of students with interdisciplinary projects, and in Croatia to create new opportunities, contribute to quality education and socioeconomic success. In the same report, Ireland planned STEM education as a common goal of the business world, government and all stakeholders, while Finland is one of the countries where STEM education is implemented most intensively compared to other countries. The same report mentions that steps have begun to be taken to make STEM education important for Turkey. In particular, the science centers that have been opened increase the curiosity of children and young people in science and technology. In this context, the science and art centers (Bilsem) in our country and the Deneyap workshops that have been opened in recent years can be seen as a result of the impact of the STEM education model on our education policies.As seen in the sample countries above, STEM education directs the education policies of countries with different purposes.

Characteristics of the STEM education model

Let's try to briefly define the STEM education model that will increase the competitiveness of countries in the 21st century. It would be appropriate to examine the STEM education model according to the study conducted by Akarsu and his colleagues (Akarsu et al., 2020). This study suggests that the STEM education model has the following ten features. The first feature is an interdisciplinary approach. The second feature is that it should be constructed with a context that has real-life social value. The third feature is that it should cover Engineering Design Processes. The fourth feature is that the decision-making process should be based on evidence. The fifth feature is that the design process should be iterative. The sixth feature is that cognitive processes in learning should be structured step by step. The seventh feature is that while learning, mistakes are made and lessons are learned from these mistakes. The eighth feature is that the process, not

the product, is important. The ninth feature is that there is no single solution, but multiple different solutions. The tenth feature is that it includes group work. Now let's take a look at these titles in a little more detail.

1- Interdisciplinary approach feature

STEM is formed by the first letters of the English meanings of the words Science, Technology, Engineering and Mathematics. The STEM education model has developed with the coming together of these four basic disciplines. Interdisciplinary interaction has increased a lot especially today. For example, when you want to develop a technological device, you primarily benefit from science fields such as Physics, Chemistry or Biology. You produce technology using engineering and mathematics infrastructures. When you want to produce a product, you benefit from each of the disciplines that give their name to the STEM education model. (Furner & Kumar, 2007).

2- The feature of being constructed with a context that has social value from real life

First of all, it is necessary to define what the concept of context is. According to Duranti and Godwin (Duranti & Goodwin, 1992) context is: 'a focal event embedded in its cultural environment.' Accordingly, designing a technological device that can kill bacteria to protect public health in the society one lives in is a context with social value. In order for the student to be able to make such a design, a correct construction or planning must be made.

3- Engineering Design Processes feature

Engineering design processes are an approach that inspires the STEM education model. In this approach, the systematic method of problem solving within the concept of engineering is explained (Moore et al., 2013, 2014). While Moore and his colleagues (Moore et al., 2013) summarized the engineering design processes as defining, learning, planning, trying and testing, English and King (English & King, 2015) summarized the engineering design processes as problem scope, idea generation, design, manufacturing, evaluation and redesign.

4- The decision-making process is evidence-based

STEM Engineering design experiences in STEM education help students connect science and mathematics knowledge as well as show connections between learning and the real world (Estapa & Tank, 2017). It follows an evidence-based path while making this connection (Crismond, 2001; Mehalik et al., 2008; Purzer et al., 2015).

5- The design process needs to be iterative

Mühendislik In the 2013 study of Moore and his colleagues (Moore et al., 2013) and in the 2015 study of English and King (English & King, 2015), it is understood that the design process is an iterative process and that the process is more important than the final

product for the STEM education model. In this process, it is seen from both studies that the design step is a step that is iterative and develops with the process.

6- The feature of step-by-step structuring of cognitive processes in learning

STEM In STEM education, cognitive behavioral gains should be planned correctly. Because STEM is an educational model that requires students to use high-level cognitive behaviors (Stohlmann et al., 2012). Therefore, the cognitive process should be carefully and correctly designed for STEM. In the literature review before STEM education, determinations regarding cognitive processes were generally made for one or two cognitive process steps (Türkkan, 2017).

7- The feature to make mistakes and learn from them

It has been stated in the literature that the process is important in the STEM education model and that the mistakes made in this process allow for different experiences to be gained. (English & King, 2015; Moore et al., 2013).

8- The feature that the process is important, not the product

In the STEM education model, the process required to reach the product is as important as the product. Because the rights and wrongs done until reaching the product are a step in the learning process. The student moves on to the next stage for everything he does right and finds the right thing by learning from the wrongs he does. Thus, he experiences many learning environments until reaching the product. It is known that the result is more important than the process in traditional education approaches. Therefore, instead of evaluations related to the process, studies on evaluations of the result are encountered in literature reviews (Dereli & Türkkan, 2005; Türkkan & Dereli, 2005).

9- There is not a single solution but multiple solutions

In a study on engineering design processes used in the STEM education model, Wang and colleagues (Wang et al., 2024) stated that one type of solution does not fit everyone due to different learning motivations. Having different solutions depending on the process and the student is a situation that can be seen in the STEM education model.

10- Group work

The importance of group work in the STEM education model has been emphasized in many studies (Moore et al., 2014; Thibaut et al., 2018). Group work in the STEM education model also supports peer education.

Conclusion

The 21st century skills that states want individuals to have in the future are almost provided by the ten features of STEM mentioned above. In this sense, states should give more place to the STEM education model in their education policies for the future. A state's ability to compete technologically

with other states in the world depends on well-educated human resources. Many states have started to implement the STEM education model in their own education systems. However, there is no unity in this application, that is, each state implements the STEM education model differently according to its own education policy and the human resources it needs. The STEM education model also includes engineering design processes due to its features. In this sense, Teknofest events held in Turkey increase the interest of young people in technology and engineering. Again, Science and art centers and Deneyap workshops opened in Turkey in recent years have increased the interest of children and young people in science and technology. Our country's bilsem and deneyap workshops have introduced young people and children to the STEM education model. However, these centers and workshops are not enough. In order for STEM education to spread more in Turkey, Science centers, Science and art centers and Deneyap workshops need to be brought together with more children and young people. In this way, a Türkiye that can produce technology and compete with other countries will be shaped.

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The Use of Artificial Intelligence in Education

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Introduction

While the number of developments in the field of information technologies is increasing day by day, it also makes our lives easier. In recent years, there have been significant developments in the field of artificial intelligence. The use of artificial intelligence in many sectors such as transport and logistics, health, automotive, education, cyber security, agriculture, mining and media is becoming increasingly widespread. Recently, artificial intelligence has paved the way for great transformations in the field of education as in many fields. When the literature is examined, it is seen that artificial intelligence applications are also used in the field of education. Artificial intelligence is used in many different areas such as evaluating student performance, personalising teaching materials, providing feedback to students, and making teacher activities more efficient. In this way, it is aimed to make the education process more effective and efficient.

Artificial Intelligence

John McCarthy, Marvin L. Minsky, Nathaniel Rochester and Claude E. Shannon first mentioned the concept of artificial intelligence in their studies presented at the Dortmund Conference in 1956. However, John McCarthy is accepted as the first person to use the concept of artificial intelligence (Alpaydın, 2013). According to McCarthy (2004), artificial intelligence is defined as the science and engineering of producing human-like intelligent machines and intelligent computer programmes.

It is possible to encounter various definitions of artificial intelligence in the literature. Some of these definitions are as follows: Artificial intelligence is a computer-controlled technology developed for the realisation of behaviours such as feeling, thinking, decision-making, reasoning and learning similar to human behaviours, which can perform behaviours and movements similar to human behaviours, created with artificial tools without using a living being (Nabiyev & Erümit, 2020). Artificial intelligence is a branch of computer science that enables the automation of intelligent behaviour and machine learning (Luger, 1998). Artificial intelligence can surpass human intelligence in repetitive and not very complex tasks (Teng, 2019). In general, when the definitions of artificial intelligence are examined, it is emphasised that various human-specific features are performed by computer-controlled machines.

There are various fields for the use of artificial intelligence. Commonly used artificial intelligence techniques are expert systems, fuzzy logic, genetic algorithms, artificial neural networks and intelligent agents (Öngöz, 2020). In addition to these, there are also areas where artificial intelligence is frequently used such as machine learning, deep learning, natural language processing, computer vision (Kalafat, 2022).

When the literature is examined, artificial intelligence is encountered in three stages: narrow artificial intelligence (Artificial Narrow Intelligencee or ANI), general artificial intelligence (Artificial General Intelligence or AGI) and super artificial intelligence (Artificial Super Intelligence or ASI).

Narrow artificial intelligence (ANI) is defined as a type of artificial intelligence in which a technology performs better than humans in tasks with a narrow scope. Narrow artificial intelligence cannot solve problems in other areas independently, but they can perform better than humans in a specific area (Kaplan & Haenlein, 2019). Narrow artificial intelligence cannot establish a cause-effect relationship and can make reasoning. For this reason, narrow artificial intelligence can only solve limited problems (Nabiyev & Erümit, 2020).

General artificial intelligence (AGI) allows a machine to apply its knowledge and skills in different fields and in a variety of applications. This type of autonomous artificial intelligence is more representative of human intelligence with its ability to establish cause-effect relationships and problem-solving skills (Davidson, 2019; Nabiyev & Erümit, 2020). AGI can independently solve problems in other domains and outperform humans in various domains. The transformation of Siri into a humanoid robot with a wide range of abilities such as voice recognition, coffee preparation and writing skills can be given as examples of such AI applications (Kaplan & Haenlein, 2019). General artificial intelligence can transfer the information it obtains to other situations, cooperate and think. Examples of general artificial intelligence are virtual assistants, applications that can produce relevant text and visuals that can organise information according to questions and requests. AGI aims to fulfil any task that a human can do. AGI is often depicted in science fiction films in situations where humans interact with machines that are conscious, sentient and can act with self-awareness (Delipetrev, Tsinaraki & Kostic, 2020).

Super artificial intelligence (ASI); It models human intelligence and thinking skills and produces even solutions that humans cannot foresee (Nabiyev & Erümit, 2020). They can quickly solve problems in other fields and outperform humans. ASI is expected to surpass human intelligence in terms of creativity, genius and problem solving. Many scientists are concerned about ASI. Currently, ASI belongs to science fiction (Delipetrev et al., 2020).

Historical development of artificial intelligence

Although artificial intelligence has been on the agenda more recently, its history is quite old. It has been revealed that various ideas about humanoid robots were carried out in ancient Greece. An example is the work of Daedelus, who ruled the wind mythology, to create artificial human beings. Modern artificial intelligence has emerged with the aim of philosophers to explain the human

thought system. The year 1884 is very important in terms of artificial intelligence. Charles Babbage tried to create a mechanical machine capable of intelligent behaviour on this date, but as a result of these studies, he understood that he could not make a machine that would exhibit behaviours as intelligent as a human (Mijwel, 2015). Artificial intelligence studies continued to develop slowly until the early 60s (Mijwel, 2015). The emergence of artificial neural networks and deep learning processors has further increased the effectiveness of artificial intelligence technologies. Currently, artificial intelligence applications are effectively used in almost every aspect of life (Altun, Uçar Altun & Kutlu, 2023).

At the centre of artificial intelligence studies is the Turing Test put forward by Alan Turing. In 1950, Alan Turing mentioned the idea of artificial intelligence with some human-like characteristics in his work 'Computing Machinery and Intelligence'. This idea is also present in the works of John McCarthy. Turing proposed a test to answer the question of whether machines can think. This test, also known as the 'imitation game', includes the following approach: When it is not known whether a machine or a human performs a task, the machine passes the test (Smith, Ting Huang, Yang & McGuire, 2006).

The period between 1965 and 1970, when developments in artificial intelligence were too few to be tested, is considered to be a dark period for artificial intelligence. Unrealistic expectations and a hasty, optimistic attitude led to the idea that it would be easy to produce machines with intelligence. However, the idea of creating intelligent machines by simply uploading data did not succeed. Between 1970-1975, artificial intelligence studies accelerated. Artificial Intelligence started to be used in large projects as of the 1980s (Mijwel, 2015). Today, artificial intelligence is used in many fields to eliminate problems in daily life.

Ethical and legal principles of artificial intelligence

The idea that AI systems should be prepared in a way that respects human values so as not to violate human rights and not be biased is commonly referred to as 'trustworthy AI (TRA)' (Efe, 2021). In 2018, the European Commission commissioned the High-Level Expert Group on AI (HLEG) to prepare ethical guidelines for trustworthy AI (Delipetrev et al., 2020).

An AI system should have three characteristics to be trustworthy (HLEG 2019):

1. Comply with all laws and regulations,

2. Committed to ethical principles and values,

3. It must be both technically and socially reliable.

Because even with good intentions, an AI can cause unintentional harm. Because even with good intentions, an AI can cause unintentional harm.Each of these characteristics is necessary but not sufficient on its own. Ethical principles prepared for AI often support and reproduce legal norms and principles (Carrillo, 2020).

The Role of Artificial Intelligence in Education

AI is one of the effective methods used to customise the experiences of different educational stakeholders (Churi, Joshi, Elhoseny & Omrane, 2023). AI technologies can enable the creation of a qualified educational environment. The widespread use of the general network has made AI an indispensable part of daily life. The needs in education have increased the importance of applications of AI that can be used in education. Smart books, web browsers and learning platforms in all areas of education are among the examples of these applications (Çinici, 2023).

Artificial Intelligence in Education (AIED) includes AI-supported exploratory learning, analysis of student writings, intelligent agents in game-based environments, AI-supported chatbots, individualized instruction and dialogue, controlling students' individual learning processes (Holmes, Bialik & Fadel, 2019; Chiu, Xia, Zhou, Chai & Cheng, 2023). The aim of using AI in the education process is to prepare a more effective and personalised learning environment for students (Chen, Chen, & Lin, 2020).

Artificial intelligence technologies can improve the educational process through the use of intelligent tutoring systems, chatbots, robots, learning analytics dashboards, adaptive learning systems and automatic assessment. Chatbots are developed with the help of technologies such as natural language processing (NLP), machine learning, deep learning and artificial neural networks. With these technologies working in harmony with each other, chatbots can interact with humans, understand human language and respond to humans (Chen et al., 2020). ChatGPT, one of the AI technologies used in many fields in recent years, is frequently used in education. ChatGPT is a chatbot offered by the OpenAI company. ChatGPT is based on the GPT-3.5 model used in natural language processing (Birer, 2023).

The impact of AI in education is not fully known (Holmes, Hui, Miao & Ronghuai, 2021). More research is needed to understand whether and how AI can be useful in education. The low awareness of AI technologies makes it difficult to use them in schools and universities (Hussin, 2018). Over time, concerns about AI in education have decreased and classical methods have gradually been replaced by AI (Churi et al., 2023). However, Jimenez and Boser (2021) stated that the use of qualified teaching materials and effective teaching methods with the help of AI increases students' achievement and helps them learn faster.

Use of artificial intelligence in education in the world

The development and popularity of artificial intelligence technologies affect all areas and thus the whole society. Therefore, it is necessary to consider artificial intelligence systems when planning the education systems of countries (Demir, 2019). Countries are affected by artificial intelligence technologies even if they do not use them directly. The USA, Russia, China and European countries, which are leading in AI development, are making large investments in the field of AI (Aydın, 2019). Zawacki-Richter, Marín, Bond & Gouverneur (2019) stated in their research that the countries with the highest number of publications on the use of AI in education are the USA,

China, Taiwan and Turkey, respectively.

In Russia, artificial intelligence courses have been included in the curriculum in schools as of 2021. In China, elective artificial intelligence courses are taught in primary and secondary schools and books on artificial intelligence are taught in many schools (Nabiyev & Erümit, 2020). SquirrelAI, an artificial intelligence-supported adaptive education programme in China, ALEKS, an adaptive artificial intelligence programme developed by McGraw-Hil in the USA, Watson, an artificial intelligence programme designed by IBM in the USA, provides students with personalised learning, and the 'third space learning' artificial intelligence programme in the UK allows students to have online lessons with a teacher (İşler & Kılıç, 2021).

In Turkey, artificial intelligence trainings are provided by the Ministry of National Education and there are departments and programmes in universities that provide education in the field of artificial intelligence. In addition, many institutions and organisations organise artificial intelligence trainings and carry out studies in this field. Artificial intelligence supported digital assistant, MEB Assistant and EBA applications have been developed by the Ministry of National Education. These applications aim to support teachers, students and parents in educational processes. It provides digital course materials to teachers, homework and exam information to students, and information about the academic status of students to parents.

Stakeholders of artificial intelligence in education

Artificial intelligence technology is leading to major changes in education. Students, parents, teachers, and educational institutions, which are the stakeholders of AI in education, should understand the importance of AI tools, because as the world changes, the understanding and methods of education in schools will also change (Baker & Smith, 2019). How and Hung (2019) stated in their study that AI assists teachers and should be used in education to improve learning outcomes.

Student-oriented AIED consists of software that responds to the personal needs of the student, which they use to receive and understand new information. Learner-facing tools are often referred to as 'intelligent tutoring systems' or 'adaptive', 'personalised' or 'differentiated' learning platforms. These student-oriented tools should have features such as developing teaching materials in line with the needs of the student, identifying the strengths and weaknesses of the student, providing automatic feedback, and enabling collaboration between students.

AIED for teachers helps teachers to lighten their workload, gain insights about students and innovate in their classrooms. AIED applications for teachers should include features such as automating tasks (assessment, plagiarism detection, management or feedback, etc.), providing insights about a student or class, providing opportunities to improve the teacher's role, supporting teachers to experiment and innovate in their teaching processes, creating classroom seating plans to reduce behavioural problems, and creating small groups to work with collaborative learning (Baker ve Smith, 2019). AIED is a technology that aims to assist teachers instead of trying to replace them (Zhao & Liu, 2019). Teachers are free to choose when and how to use AIED tools (Luckin, 2018).

System-oriented AIED helps education managers and school administrators to make educational decisions. Usually system-oriented AIED tools require data sharing between schools. Although system-oriented AIED tools are the least developed category, they are used for a wider distribution of tasks than educator- or student-oriented tools, from preparing syllabuses to conducting inspections (Baker & Smith, 2019).

In terms of school management, teachers, students and parents, AEID provides some facilities to the stakeholders. In terms of parents, AEID can be used, for example, by working parents who have a child with special educational needs and can establish interactive interactions between parents and their children (Alanoğlu and Karabatak, 2020).

When AIED is examined according to recent years, the area that has seen the most improvement among the educational organisation, parents, teachers and students is the student and the learning process (Çetin & Aktaş, 2021). Loeckx (2016) suggested that AIED can be an effective learning tool that eases the burden of both teachers and students and provides effective learning experiences for students.

Impact of artificial intelligence on the learning process

When the studies on AIED were reviewed in the literature, it was encountered that most of the studies were conducted in the student-oriented field (Baker & Smith, 2019). Chen et al. (2020) stated in their study that AI applications are used in various ways to promote student learning. Individualisation of the curriculum in line with the needs and abilities of the student is one of the important points used by AI to improve learning (Mikropoulos & Natsis, 2011). Approaches that provide students with a more enjoyable, inclusive and experiential learning environment generally create a more effective learning process. A learning environment prepared in this way generally increases students' motivation and interest in learning and ensures that the information learnt is permanent (Mikropoulos & Natsis, 2011; Wartman & Combs, 2018). AIED can create a global learning environment through online and web-based platforms by increasing access to learning opportunities across national and international borders (Sharma, Kawachi & Bozkurt, 2019; Mikropoulos & Natsis, 2011).

Some AI platforms enhance the student's learning experience by enabling individualisation of content, retrieval and storage of information. Knewton application personalises course materials or content according to students' needs (Chassignol, Khoroshavin, Klimova & Bilyatdinova, 2018). Pokrivcakova (2019) stated that AI applications such as Cerego, Immersive Reader and CALL improve student learning and provide students with a more customised, interactive and efficient learning environment.

The role of teachers in the use of artificial intelligence in education

The role of teachers in the use of artificial intelligence in education is very important. By using AI applications correctly and effectively, teachers can support students' learning processes, provide customised learning experiences in line with their personal needs and customise teaching

materials according to students' interests.

AI will lighten the workload of teachers and enable them to use their time efficiently in the teaching process. In addition, it also supports teachers to plan classroom activities, monitor student achievement performance and evaluate assignments. AI-supported materials can facilitate the learning process by developing up-to-date and appropriate content on the subjects learnt. At the same time, by going beyond simple methods with effective content, it gives the opportunity to keep the student's interest alive (Aşık, Yıldız, Kılınç, Aytekin, Adalı, & Kurnaz 2023; Bulut, Davarcı, Bozdoğan, & Sarpkaya, 2024). The preparation and control of homework and exam content with the help of automated systems enables teachers to make their time more efficient. Thus, teachers can communicate with more students one-to-one and provide more support to them. In addition, with the help of automated systems, students can be given immediate feedback and their deficiencies can be detected and corrected faster (Bulut et al., 2024). Chen et al. (2023) stated that AI technologies contribute to the interaction between teachers and students and the learning process.

Teachers' roles have been changing recently due to the impact of AI technologies. Teachers can take on more roles than transferring traditional knowledge. AI, teachers' mentoring and guiding roles allow students to discover and develop their individual capacities more effectively (Yolcu, 2024). In this way, students become aware of their own skills. The use of AI technology in individualised learning can improve the quality of education by supporting teachers' professional development. Artificial intelligence offers teachers the opportunity to create more effective teaching materials and strategies with the ability to respond more carefully to student needs (Tapalova & Zhiyenbayeva, 2022).

In traditional teaching environments, teachers usually try to teach by taking into account different student profiles in the classroom. However, AI technologies can make this process even more effective. By tracking student performance, AI can provide feedback to students and adjust the teaching process according to their individual needs (İşler & Kılıç, 2021).

With the help of AI, teachers can use various digital tools and platforms to improve students' creativity, critical thinking skills, and problem-solving abilities (Darwin, Rusdin, Mukminatien, Suryati, Laksmi, & Marzuki, 2024; Yolcu, 2024). For example, programming platforms such as Scratch offer students the opportunity to develop their coding skills. In addition, interactive quiz applications such as Kahoot help students make learning fun.

Advantages and disadvantages of using artificial intelligence in education

In recent years, societies accustomed to technologies have largely adopted artificial intelligence-supported tools with the influence of social media. The adaptation of artificial intelligence to education brings both existing advantages and some disadvantages that need to be considered.

AI provides an individualised approach, especially in different countries or when one-to-one instruction is costly and difficult to access (Chen et al., 2020; Kengam, 2020; Leoste, Jõgi., Õun, Pastor, San Martín López & Grauberg, 2021). With the use of AI, learning gaps are identified,

pedagogical methods are developed, content to be taught can be customised and students are provided with learning experiences to increase their academic achievement (Kengam, 2020). In her study, Pokrivcakova (2019) stated that artificial intelligence provides the possibility of developing and using intelligent learning systems and individualised content for the learning needs and abilities of each student. For example, simulation teaching and learning prepared with virtual reality (VR) technology positively affects the learning process. The studies of Rus, D'Mello, Hu, & Graesser (2013) mentioned that intelligent tutoring systems support deep learning and encourage students to express themselves well with conversational tools, thus supporting learning by facilitating information retrieval and retention. In summary, the use of AI technologies helps to deepen learning processes and create more effective learning environments.

AI ensures that learnt information is regularly reviewed, retained in long-term memory and not forgotten (Owoc, Sawicka, & Weichbroth, 2019). AI supports teachers in the process of grading assignments, identifies students' learning gaps and helps to make suggestions on these issues (Mikropoulos & Natsis, 2011; Kengam, 2020).

AI-enabled systems provide a variety of learning opportunities for individuals who speak different languages and have hearing or visual difficulties. Applications such as presentation translator can translate speech into text or subtitles using AI technologies. Voice assistants such as Google Assistant, Cortana, Siri and Alexa help students to speak directly to educational materials on the internet and on installed devices without any intervention from their teachers (Kengam, 2020).

The use of AI and other new technologies brings with it various concerns. These concerns include privacy violations, data security risks, bias and discrimination (Pisica, Edu, Zaharia & Zaharia, 2023). The cost of AI technologies is usually high as specialised personnel, high-tech equipment and software are required to develop, implement and continuously update AI systems (Kengam, 2020; Al-Tkhayneh, Alghazo & Tahat, 2023). Therefore, the limits of the use of artificial intelligence should be carefully determined and the outputs should be supervised and controlled (Uyan, 2023). A joint effort by educators, researchers, and policy makers is required for the use of AI technologies in accordance with ethical principles in education (Adıgüzel, Kaya, & Cansu, 2023). It is of great importance to comply with the principles of ethics and responsibility during the use of AI technologies (Adıgüzel, Kaya, & Cansu, 2023; Uyan, 2023).

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An Artificial Intelligence Application in Science Education: ChatGPT

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Introduction

The rapidly changing field of educational technology is fundemental to changing the confront of teaching and learning (Farrokhnia, Banihashem, Noroozi, & Wals, 2023). Artificial Intelligence is one of the foforemost revolutionary technological advancements that has affected education. According to Mhlanga (2023), intelligence (AI). AI in education (AIEd) has drawn a part of consideration over the past forty years owing to its potential to significantly improve learning, teaching strategies, and administrative duties in educational environments (Chiu et al., 2023). Large language models (LLMs), a particular kind of AI calculation that uses artificial neural networks (ANNs) and hugely expansive information sets to comprehend, summarize, produce, and foresee modern substance that's about inconceivable to recognize from human manifestations (Zhai, 2022), have created new opportunities for improving a variety of educational aspects, including personalized instruction and content creation (Valtonen & Mäkinen, 2022). By interacting with students, providing prompt assistance, and encouraging interactive learning situations, chatbots that take utilize of LLMs' capacity to comprehend and create human-like reactions have moreover appeared promise in improving student learning and educational results (Bozic & Poola, 2023). The uncommon and nonstop mechanical advancements in chatbots have expanded their potential for sending over different spaces and made their utilize more helpful, characteristic, and easy (Baidoo-Anu & Ansah, 2023) A later well-known AI-powered innovation that has affected the education part is ChatGPT. The aim of this research is to provide information about what the ChatGPT artificial intelligence model is, its positive, negative aspects and limitations, and methods to overcome the negative and limitations.

Artificial Intelligence

Educational technology, which has created quickly in later a long time, plays an awfully vital part in improving the instructing and learning environment (Valtonen & Mäkinen, 2022). One of the foremost imperative advancements in instructive innovation is Artificial Intelligence (Mhlanga, 2023). Artificial Intelligence was created by John McCarthy in 1955 and is characterized as the capacity of a machine to effectively perform errands that are considered brilliantly (McCarthy, Minsky, Rochester, & Shannon, 1955). Kurzweil (1990) characterizes artificial intelligence as the craftsmanship of creating machines that can perform errands that require human insights (Adıgüzel, Kaya, & Cansu, 2023). Artificial intelligence may be a field of consideration that points

to deliver computers and machines with human-like insights (Coppin, 2004) and the coming about developments and advancements (Chen, Xie, Zou, & Hwang, 2020). Artificial intelligence is additionally characterized as a subfield of computer science that focuses on examining the basic nature of intelligence by employing a set of algorithmic strategies to make artifacts that take after human insights (Dwivedia, et al., 2021). In other words, artificial intelligence points to mimic the mental aptitudes of the human brain such as issue understanding, choice making, expectation and induction (Aktay, Gök, & Uzunoğlu, 2023). Artificial intelligence is accomplished by understanding how the human brain works, as well as how people learn, choose and work when attempting to solve issues, and after that leveraging the comes about of this inquire about to form cleverly program and frameworks (Bozic & Poola, 2023). To provide a more comprehensive definition; any hypothesis, strategy or strategy that encourages examination, recreation, utilization and investigation of human considering forms and behaviors by machines, particularly computers, can be considered artificial intelligence (Lu, 2019).

The main purpose of artificial intelligence is to form a framework that learn, show, explain, advise, comprehend, think and act like humans. In addition, performing tasks such as voice recognition, learning, planning and problem solving are also among its objectives (Bozic & Poola, 2023). Thanks to the fast advancement of artificial intelligence, instruction and learning innovations, its utility in instruction includes a critical effect on the way we learn (Chen, Xie, Zou, & Hwang, 2020).

Artificial Intelligence in Education

Since the 1980s, artificial intelligence in education (AIEd) has been built up as a coherent field of academic study (Williamson & Eynon, 2020). In AIEd, two approaches are received: the advancement of AI-based devices for classrooms and the knowledge and evaluation of learning (Holmes, Bialik, & Fadel, 2019). Ouyang and Jiao (2021) categorized artificial intelligence in education (AIEd) into three paradigms: AI-driven, where the student is seen as a collector, and AI-supported, where the student is seen as a collaborator and pioneer. To begin with worldview, AI is utilized to speak to and direct cognitive learning, whereas students are the recipients of AI administrations. Within the moment worldview, which has cognitive and social constructivist hypothetical establishments, students collaborate with AI whereas AI underpins learning. Within the third worldview based on connectionism, AI enables learning whereas students intervene in their own learning, supporting the solid collaboration between students, teachers, data and innovation within the framework. In this regard, artificial intelligence within the field of instruction is recognized as a effective device that empowers modern ideal models in directions plan, mechanical headway and instructive inquire about that cannot be accomplished with conventional instructive strategies. This property is thought to be related to the integration of social, cultural, financial and educational measurements (Lu,2019).

Whereas the effect of AI on education is still dubious (Holmes, Bialik, & Fadel, 2019), it has noteworthy potential to move forward learning, instructing, academic developments, evaluation, and educational organization (Chen, Xie, Zou, & Hwang, 2020In expansion to its potential to

revolutionize education, it requires more than the utilize of progressed AI computing innovations to attain positive educational results (Castañeda & Selwyn, 2018). The utility of innovation ought to be closely connected to speculations of educating and learning to direct guidelines plan and innovative progression, particularly in AI (Bower, 2019). As for the conceptual system of AI-assisted learning, Zheng et al. (2021) contend that the utilization of AI innovations, learning substance and educational approaches are regularly interconnected and ought to be thoroughly coordinated into learning situations to guarantee learning proficiency and effectiveness. When planning learning exercises bolstered by AI, teachers and professionals ought to consider six vital components to attain the anticipated learning objectives: learners, themes, assignments, academic approaches, interaction strategies, and application of AI innovations (Zheng, Jiayu, Zhong, & Gyasi, 2021).

Artificial intelligence provides instructors with time and flexibility as well as efficiency, personalization and simplified activities (Bozic & Poola, 2023). In the future, as AI solutions advance to a higher level, they will help identify gaps in teaching and learning and increase educational competence (Adıgüzel, Kaya, & Cansu, 2023). It is imperative to utilize to contribute to the method of making social and financial esteem in science, which is the field specifically influenced by current improvements in science and innovation (Bayram & Çelik, 2023). Within this regard, when we look over the literature, over numerous considers on the utilize of AI in science education. The impact of AI on pre-service science teachers' opinions on socioscientific issues (Bayram & Çelik, 2023) and the impact of AI on issue understanding and imaginative composing aptitudes of primary school students (Bor & Küçükaydın, 2021), raising awareness of pre-service science teachers (Çam, Çelik, Güntepe, & Durukan, 2021), the utilize of AI by science teachers within the remove instruction prepare (Erkoç, 2023), the impact of AI on the science handle abilities of 8th review talented understudies on seasons, DNA and pressure (Sarıoğlu, 2023), the discernments of pre-service physics teachers about AI (Erdoğan & Bozkurt, 2023), the impact of AI on the GPA of pre-service science teachers (Erdoğan & Bozkurt, 2023), the impact of AI on the science handle aptitudes of 8th grade talented students (Sarıoğlu, 2023, physics teacher candidates' perceptions about AI (Erdoğan & Bozkurt, 2023), the utilize of Artificial Neural Networks (ANN) within the classification of science educator candidates' review point averages (Yorgancı & Işık, 2019).

When we see at the utilization zones of AI innovations in education prepare incorporates numerous sorts counting shrewdly instruction frameworks, chatbots, robots, learning analytics control boards, versatile learning frameworks, and programmed evaluation (Chen, Xie, Zou, & Hwang, 2020). In later a long time, chatbots, which have gotten to be far reaching particularly within the field of education, contribute to the person improvement of students (Arruda, Marinho, Souza, & Wanderley, 2019) (Topal, Eren, & Geçer, 2021) (Nghi, Phuc, & Thang, 2019).

Chatbots

Chatbots are artificial intelligence agents that can interact with the user by providing an appropriate response to a series of questions (Clarizia, Colace, Lombardi, Pascale, & Santaniello, 2018).Therefore, chatbots permit people to connected as on the off chance that they were talking

to a genuine individual amid a discussion by to begin with understanding the substance of the discourse, distinguishing the social and passionate needs of clients, and mirroring and deciphering human communication (Chechanowski, Przegalinska, Magnuski, & Gloor, 2018).

The creation of a chatbot includes the utilization of Natural Language Processing (NLP). NLP may be a innovation that empowers a machine to get it, analyze and decipher characteristics of human dialects. Also, the execution of a chatbot depends on the size and exactness of its databases, which suggests that bigger database estimate will lead to superior execution. Figure 1 appears how a chatbot works (Aleedy, Atwell, & Meshoul, 2021).

Figure 1. *General Chatbot Workflow , Explanation note: Aleedy, Atwell, & Meshoul, 2021*
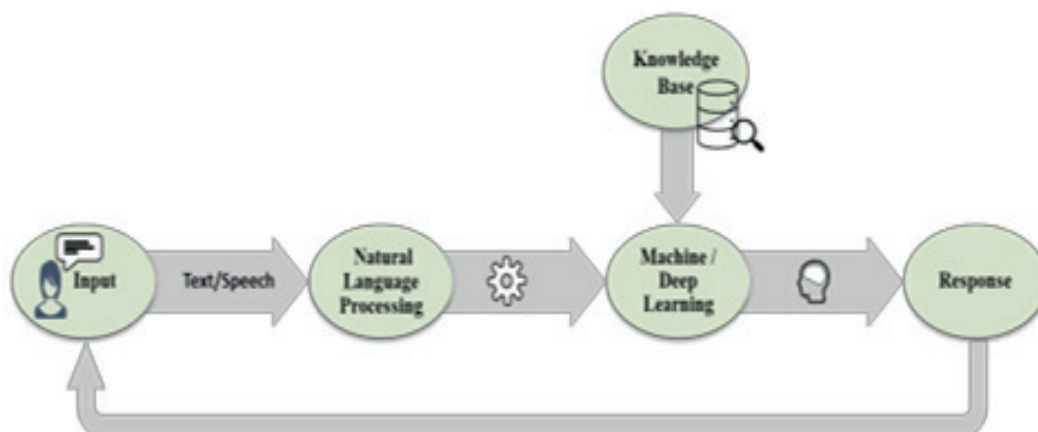
Given an incite or setting, the demonstration forms the input and gives a reaction. When preparing the input, it draws on a huge database, such as books and articles, and produces content comparable to the content on which it was prepared. The reaction is prepared reliably, each time based on the input and the words it has created so remotely. They demonstrate employments attentional components to center on the foremost pertinent parts of the input and to create a coherent reaction suitable to the given setting. It can produce content in numerous dialects by fine-tuning the multilingual figure or by giving the dialect code to the figure (Baidoo-Anu & Ansah, 2023).

Progressing and exceptional mechanical propels in chatbots have made them utilize more comfortable, progressively common and easy, and are extending their potential for sending in different areas (Schöbel, et al., 2024). In especially, the capabilities of a chatbot can shift depending on innovations such as common dialect handling, machine learning, profound learning, and counterfeit neural systems (Nirala, Singh, & Purani, 2022). Chatbots play a significant part in supporting students' learning (Kooli, 2023), improving learning encounters, and encouraging different learning approaches such as personalized learning, collaborative learning, emotional learning, and learning by doing (Kuhai, Alturki, Alramlawi, & Alhejori, 2023). Chatbots such as Alex, ELIZA, megaHAL, PARRY, ANTswers, A.L.I.C.E., Bard, Bing, Ernie, and ChatGPT have been enhanced (Kane, 2016) (Osetskyi, Vitrenko, Tatomyr, Bilan, & Hirnyk, 2020). One of the unmistakable cases of chatbot applications is the Chat Generative Pre-Trained Transformer, known as ChatGPT, which was presented on November 30, 2022 by OpenAI, one of the driving manufactured insights inquire

about research facilities (Albadarin, Tukiainen, Saqr, & Pope, 2023).

ChatGPT

ChatGPT portrays itself as "a effective machine learning computer program that employments the Generative Pre-trained Transformer (GPT) Generative Pre-trained Transformer (GPT) calculation to produce human-like reactions to text-based inputs" (Albadarin, Tukiainen, Saqr, & Pope, 2023). Generative Pre-Trained Transformers (GPTs) are prepared on a huge database, counting articles, websites, books, and composed discourse, to progress their yield (Aktay, Gök, & Uzunoğlu, 2023). This gives it the capacity to reply to prompts in a conversational way, permitting engineers to customize the dialect demonstrate for their utilize cases and make profoundly complex reactions (Halaweh, 2023). By foreseeing the following word in a sentence based on the setting of past words, and by identifying patterns and regularities within the information, it effortlessly creates human-like content, fitting expressions and pictures in reaction to the user's inquiry (Bozic & Poola, 2023). Besides, the transformer structure, based on the component of individual consideration, permits the long short-term memory (LSTM) to get a handle on the setting of the content being handled and to store data from past inputs. This permits it to analyze parts of the input, with a specific center on repetitive neural systems (RNNs), creating more characteristic and steady yield. Hence, by utilizing profound neural systems to prepare huge sums of content information and learn designs in dialect, it permits it to make coherent and syntactically rectify sentences (Lund, et al., 2023).

One of the foremost critical highlights that recognizes ChatGPT from other AI-based chatbots is that it is more effective in exercises that require imagination (Ali, Shamsan, Hezam, & Mohammed, 2023). A wide assortment of errands can be performed, counting dialect interpretation, summarizing or completing content, replying to questions, making imaginative substance (such as sonnets, articles, stories, blogs, fiction), and reacting to questions (AlAfnan, Dishari, Jovic, & Lomidze, 2023). It can give clues in discourse, clarify complex themes, concepts or topics, rectify mistakes in existing code and produce unique modern codes (Squeeze, 2023). Additionally, it not as it were distinguishing the issue but moreover gives adjust arrangements (Albadarin, Tukiainen, Saqr, & Pope, 2023).

ChatGPT's capacity to get it normal dialect inquiries and create human-like reactions has made it a well-known apparatus for getting fast answers to a wide extent of questions, from common to complex points (Lo, 2023). For this reason, the most recent adaptation of ChatGPT (ChatGPT-4), prepared on a bigger and more different dataset and claimed to be able to perform more effective and complex capacities, was created and discharged on Walk 14, 2023 (Ratnam, Sharma, & Tomer, 2023). The expanded measure of the demonstration permits for more progressed characteristic dialect preparing capabilities, much obliged to its capacity to reason and get it headings in different spaces, and to end up more versatile and finish challenging errands (Roumeliotis & Tselikas, 2023). For case, in the event that a client sends a picture and demands a depiction, it depicts the picture in detail inside a number of seconds (OpenAI, 2023). Google search results, which are popular and easy to access, are based on websites that the Google algorithm identifies as relevant to your

search query, while ChatGPT provides direct answers from a large and comprehensive database, as they are programmed with a specific set of knowledge and rules to generate answers (Singh, Kumar, & Mehra, 2023). Figures 2 and 3 show the answers given by both Google search engine and ChatGPT to the question 'What is artificial intelligence?

Figure 2. *Answer provided by Google Search Engine*

Figure 3. *Answer provided by ChatGPT*

Moreover, the wide and comprehensive capacity of ChatGPT can lead to changes in learning goals, learning activities and assessment practices. Its impact in these areas is thought to be very large (Farrokhnia, Banihashem, Noroozi, & Wals, 2023) (Zhai, 2022). In this context, it is important to emphasize the positive, negative and limiting aspects of ChatGPT.

Positive Aspects of ChatGPT

There are numerous positive perspectives of utilizing ChatGPT in education for students (Albadarin, Tukiainen, Saqr, & Pope, 2023).

- **Personalized Learning**: ChatGPT can supply personalized learning encounters based on the learner's level of understanding by fitting substance and clarifications to the individual's needs and pace, giving challenging questions when essential, and disentangling concepts (Oranga, 2023). It can analyze student designs and inclinations and suggest learning assets such as articles, recordings, and reading material that fit their needs (Bozic & Poola, 2023). A ponder by Chen et al. (2020) appeared that ChatGPT can give students with personalized arithmetic lessons, give fitting clarifications for students' misguided judgments, and adjust to their level of understanding, which can lead to superior learning results. A think about by Chiang and Lee (2024) appeared that ChatGPT can give more successful back to students learning programming and progress execution on programming evaluations. The consider moreover demonstrated that the show can get it students' information and alter the trouble of the issues in like manner (Albadarin, Tukiainen, Saqr, & Pope, 2023), (Fırat, 2023), (Rahman & Watanobe, 2023), (Zhu, Sun, Luo, Li, & Wang, 2023).

- **Creating adaptive tests:** It can be utilized to make versatile tests that alter to each student's level of trouble, permitting for more precise and successful evaluation of information and aptitudes (Bozic & Poola, 2023).

- **Alternative assessment methods:** Alternative assessment methods such as intelligent recreation and diversions can be utilized to make more locks in and bona fide evaluation involvement for students (Bozic & Poola, 2023) (Oranga, 2023).

- **Self-directed learning:** It permits students to require duty for their claim learning and create the abilities and approaches essential for their victory (Fuchs, 2023). It moreover changes them into advocates of their possession learning through increased motivation and victory within the learning prepare (Crawford, Cowling, & Allen, 2023)

- **24/7 Availability:** ChatGPT allows students to access information and help whenever and wherever they need it (Khan, Ahmad, Jabeur, & Mahdi, 2021, Oranga, 2023).

- **Accessible Learning:** It makes learning more accessible for individuals with visual or hearing impairments through different and specialized text-based interactions (Farrokhnia, Banihashem, Noroozi, & Wals, 2023).

- **Instant Feedback:** ChatGPT gives moment input on assignments, tests, and questions, making a difference understudies get their mistakes and adjust them quickly (Kuhai, Alturki, Alramlawi, & Alhejori, 2023).

- **Extensive Knowledge Base**: Prepared on a wide run of sources and able to supply clarifications, definitions and cases on different subjects (İşler & Kılıç, 2021).

- **Providing Accurate and Clear Information**: It can answer user questions accurately by processing information in an accurate, efficient, systematic and informative manner (Zhang, Lu, Zhu, & Zhang, 2023). Within the study carried out by Topal et al. (2021), within the "States of Matter" unit of the 5th grade Science course, students were able to inquire all sorts of questions to ChatGPT and the chatbot replied all the questions of them. After this consideration, the ones expressed that they seem to get data around the courses and other areas from ChatGPT. According to Brandtzaeg and Folstad (2017), one of the foremost common reasons why individuals (aged 16-55) incline toward chatbots is to get data. In brief, ChatGPT is for the most part utilized to supply data to clients and reply to their questions rapidly (Rasul, et al., 2023).

- **Language Learning**: It makes a difference dialect learning by reenacting real-life discussions and giving students with corrections on language structure (Brandtzaeg & Følstad, 2017), enhancing language abilities and giving moment input on vocabulary (Lin & Chang, 2020). A study by Kim (2021) searched the utilize of ChatGPT in language learning and found that it is successful in enhancing students' English language skills and is profoundly evaluated by students.

- **Language Translation:** It can be utilized to decipher instructive materials into distinctive dialects and make them more open to a more extensive group of audience (Beam, 2023). A research by Jeon and Lee (2023) appeared that ChatGPT can get it the meaning of sentences in a dialect and precisely interpret between dialects by accomplishing state-of-the-art comes about in different interpretation criteria.

- **Study Help:** Making a difference students with inquire about by summarizing articles, making citations, or proposing extra readings and sources (Jeon & Lee, 2023).

- **Writing assistance:** It can give feedback on linguistic use, accentuation, and spelling mistakes by analyzing students' composing style and proposing advancements (Pokrivcakova, 2019). Lin and Chang (2020) found that the prompts created by ChatGPT to reinforce students' composing abilities made a difference in students create more different and complex thoughts for their composing assignments.

- **Conceptual Reinforcement**: By helping students gain a deeper understanding, it helps them understand difficult concepts more easily through discussion and practical problems and strengthens their understanding (Liu, Subbareddy, & Raghavendra, 2022).

- **Conversational Learning:** By engaging students in conversational interactions, it also encourages active learning and critical thinking and is particularly useful in developing communication skills (Kim, 2021).

- **Collaborative Learning:** It encourages collaborative learning by making a difference students work together on group tasks or problem-solving duties (Grudin & Jacques, 2019).

- **Interactive Learning:** It can be utilized to make intelligently learning encounters where students can connect with a virtual mentor through chat (Albadarin, Tukiainen, Saqr, & Pope, 2023). A study by Peng et al. (2023) appeared that ChatGPT can give compelling back to learners of English as a second language, where the operator can detect the students' questions, give suitable and sensible reactions, and as a result, language capability can improve (Peng, et al., 2023).

- **Exposure to Different Perspectives:** It encourages open-mindedness and critical thinking by providing students with different viewpoints and perspectives on various topics (Oranga, 2023).

- **Flexibility:** Adapts to diverse learning styles and choices, whether students prefer reading, listening or conversational arguments (De Castro, 2023)

- **Affordability**: Using ChatGPT is cost-effective as it eliminates the need to hire additional human trainers or instructors, providing accessibility to information without having the resources (Su & Yang, 2023).

- **Scalability:** It can be scaled to get a huge number of learners at the same time for both person and gather learning situations (Oranga, 2023).

- **Automatic grading:** It can be utilized to consequently review essays and other written tasks. This spares teachers a part of time and gives students prompt input on their work (Albadarin, Tukiainen, Saqr, & Pope, 2023). It can give precise, steady and objective task (Bozic & Poola, 2023). A study by Khan et al. (2021) appeared that ChatGPT can precisely review papers composed by tall school students with a relationship of 0.86 with human grades. The think about appeared that the demonstration was able to distinguish key highlights of well-written papers and give input comparable to that given by human raters (Khan, Ahmad, Jabeur, & Mahdi, 2021).

- **Facilitated lesson planning:** It can be utilized to create educational program and make lesson plans and educating materials based on particular learning gains (Bozic & Poola, 2023).

- **Text analysis**: By identifying patterns and trends in the language used, it assists researchers in analyzing and comprehending vast amounts of text data, such as news articles or posts on social media. (Peng, et al., 2023).

- **Learning by having fun:** It is seen as engaging and exciting for students and they claimed that they learn by having fun (Kolchenko, 2018).

- **Offering different learning approaches:** Creating, supporting and presenting new learning approaches to improve the learning process and outcomes (Vartiainen & Tedre, 2023) and facilitating their implementation (Deng & Yu, 2023). It can also demonstrate how teachers can embrace or create fresh, successful teaching and learning methods that

might emerge. (Sonderegger & Seufert, 2022).

- **Improving thinking abilities:** It greatly enhances students' capacity for original and creative thought as well as their retention, reasoning, and analysis skills. (Liu, Subbareddy, & Raghavendra, 2022).

Negative Aspects of ChatGPT

Although ChatGPT has a lot of promise in a number of areas, including education, it also has a number of drawbacks and difficulties. Because of its negative aspects, the extensive use of ChatGPT in education has sparked some worries. (Oranga, 2023). To mention the negative aspects:

- **Lack of Critical Thinking**: ChatGPT only generates answers based on patterns in the data it has been trained on because it lacks the ability to truly comprehend and think critically. As a result, these answers might not always be correct or logical. (AlAfnan, Dishari, Jovic, & Lomidze, 2023).

- **Data Dependency:** The quantity and quality of the data in the database that ChatGPT uses is crucial because it is trained on a lot of data. The model might not function as well if the data is insufficient or irrelevant (De Castro, 2023). It was highlighted in a study by Peng and colleagues (2023) that when the training data is unrelated to the task at hand, a ChatGPT-based question answering system does not function as well as intended.

- **Limited Context Awareness**: ChatGPT lacks an in-depth understanding of the wider context and can sometimes produce inappropriate or meaningless responses that are irrelevant (Oranga, 2023). Its capacity to comprehend and produce contextually relevant responses in a conversation is limited, according to a study by Ali et al. (2023) (Ali, Shamsan, Hezam, & Mohammed, 2023).

- **Vulnerability to Bias**: Biased or discriminatory responses could result from the model inadvertently reinforcing preexisting biases in educational data (Mhlanga, 2023). For instance, a model may not accurately grade essays written by students from other demographic groups if it is trained on a dataset that primarily consists of essays written by students from that group (De Castro, 2023). According to a study by Alafnan et al. (2023), ChatGPT displays gender bias in its language production.

- **Failure to Verify Information**: Although ChatGPT offers information, it is unable to confirm that this information is accurate. As a result, users ought to assess the information offered critically (Zhu, Sun, Luo, Li, & Wang, 2023).

- **Limited Subject Knowledge**: Despite having access to a wealth of information, they might not be knowledgeable about certain crucial subjects and their understanding may be out of date (Gilson et al., 2022).

- **Risk of Misinformation**: Using ChatGPT exclusively to obtain information can result in the unintentional spread of inappropriate and erroneous information, particularly when it comes to contentious or quickly changing subjects. Despite having a sizable database, it cannot take the place of books in this situation (Alkaissi & McFarlane, 2023). In one study, Oadir (2023) asked ChatGPT to write an article, and a book based on an article he was working on. ChatGPT included an article that didn't exist and even gave him the article's bibliographic information with a non-functional URL (Qadir, 2023).

- **Privacy Concerns**: Conversations with ChatGPT can be recorded and stored, potentially leading to privacy concerns if sensitive or personal information or data is shared (Ray, 2023).

- **Lack of Emotional Intelligence**: When ChatGPT lacks emotional intelligence and empathy, it is unsuitable for offering counseling or emotional support (Jeon & Lee, 2023). Students who engaged with a virtual tutor who exhibited human-like emotional behavior outperformed those who engaged with a virtual tutor who did not, according to a study by Chechanowski et al. (2018) (Chechanowski, Przegalinska, Magnuski, & Gloor, 2018).

- **Over Reliance on Technology:** Overuse of artificial intelligence such as ChatGPT can lead to overreliance and overdependence on technology (Arruda, Marinho, Souza, & Wanderley, 2019). In addition to extended radiation exposure, this results in deficiencies in critical thinking abilities and learning independence (Aktay, Gök, & Uzunoğlu, 2023).

- **Unpredictable Responses**: Unpredictable or inappropriate responses that may cause problems in educational or professional settings, and may also produce responses that are inappropriate for the age of the student (Kolchenko, 2018)

- **Lack of Real World Experience**: Since there is no real-world experience, it cannot provide practical advice based on personal experiences (Kolchenko, 2018).

- **Failure to Meet Individual Needs**: ChatGPT cannot truly comprehend the concepts they teach students because it is based on statistical patterns in the data it is trained on (Aleedy, Atwell, & Meshoul, 2021). As a result, it finds it difficult to offer clarifications or feedback that are specific to the needs and misconceptions of each learner. Additionally, because it is unable to follow one-on-one interactions and needs, it is unable to satisfy the unique requirements of the user (Baidoo-Anu & Ansah, 2023). According to a study by Clarizia et al. (2018), ChatGPT was unable to offer explanations that were specific to the misconceptions of the students (Clarizia, Colace, Lombardi, Pascale, & Santaniello, 2018).

- **Language Limitations**: It may not be equally proficient in all languages and its performance may vary depending on the language with which it interacts (Chiang & Lee, 2024).

- **Security Risks**: It can be utilized to produce damaging or immoral content, including spam, scams, and fake news (Farrokhnia, Banihashem, Noroozi, & Wals, 2023).

- **Lack of Social Interaction**: Despite ChatGPT's ability to mimic conversations, it cannot take the place of in-person social and emotional interactions and may result in a decline in empathy as well as a lack of communication and social skills (Ray, 2023).

- **Plagiarism**: Plagiarism and academic dishonesty may result from students using ChatGPT to produce written work without giving due credit or obtaining permission to use it (Day, 2023). According to data presented by Hisan and Amri (2023), students who used ChatGPT in their writing assignments were more likely than those who did not to engage in plagiarism. Furthermore, a number of studies have demonstrated that ChatGPT-generated text is imperceptible by plagiarism detection software like Turnitin, despite the fact that features like the absence of errors, consistent style and tone, and the use of sophisticated vocabulary and sentence structures may raise suspicions (AlAfnan, Dishari, Jovic, & Lomidze, 2023).

- **Difficulty in Objective Assessment**: Due to the difficulties in plagiarism and plagiarism detection, there are difficulties in accurately assessing papers and student performance (Rudolph, Tan, & Tan, 2023).

- **Lack of Creativity and Originality**: ChatGPT can limit the creativity and originality of responses and diminish higher-order thinking skills because it can only produce responses based on patterns in the data it observes during training (Su & Yang, 2023). The ability of ChatGPT to generate unique and varied melodies in a music composition system is limited, according to a study by Rasul et al. (2023).

- **Technical Requirements**: Some users may find it difficult to use ChatGPT because it requires technical hardware and background knowledge, such as high-speed internet, access to computer resources, and specialized software. (Oranga, 2023).

When choosing whether and how to use ChatGPT in education, it's critical to take these negative aspects and limitations into account (Aktay, Gök, & Uzunoğlu, 2023). These limitations can be lessened and the potential advantages of ChatGPT in education can be maximized with the support of proper training, observation, and assessment (Adıgüzel, Kaya, & Cansu, 2023).

Methods to Overcome the Negative Aspects and Limitations of ChatGPT

It is crucial to approach the use of GPT technology in the classroom responsibly and thoughtfully, considering both the possible advantages and difficulties and working to get past any limitations that might appear (Aleedy, Atwell, & Meshoul, 2021). All students' educational experiences can be improved and made more enriching by doing this with GPT technology (Halaweh, 2023). Ways to overcome these challenges and limitations are;

- **Diversifying training data:** By gathering data from multiple sources and making sure that the data is devoid of bias and inaccuracy, diverse and representative training data can be used to address bias and inaccuracy issues (Bozic & Poola, 2023).

- **Providing contextual and critical thinking skills**: Giving students the context and critical thinking abilities they require to decipher and evaluate the language generated by ChatGPT is essential to overcoming their lack of contextual understanding (Halaweh, 2023).

- **Encouraging higher-order thinking skills:** Critical thinking and problem-solving abilities should be promoted in addition to the use of the generated content to lessen the possibility that students will grow unduly reliant on ChatGPT technology (Bozic & Poola, 2023).

- **Including alternative assessments**: Alternative assessments such as projects, essays, and presentations should be included alongside ChatGPT to prevent cheating (Aleedy, Atwell, & Meshoul, 2021). Moreover, to leverage the power of ChatGPT and build professional capacity, teachers should support students in high-quality assessment practices that enhance student learning (Aktay, Gök, & Uzunoğlu, 2023).

- **Providing technical support and training**: Access to specialized software and computer resources, as well as technical support and training, are necessary to guarantee that educators and learners can utilize ChatGPT technology in the classroom (Castañeda & Selwyn, 2018). Furthermore, institutions and organizations should carefully plan ChatGPT implementations, provide clear guidelines for its use, invest in ongoing monitoring and maintenance, and offer alternatives to users who need more complex or personal assistance (Holmes, Bialik, & Fadel, 2019). Furthermore, managing expectations and guaranteeing a satisfying user experience can be achieved by informing users about ChatGPT's features and limitations (Clarizia, Colace, Lombardi, Pascale, & Santaniello, 2018). According to a study by Ali et al. (2023), people who lacked the requisite ChatGPT skills discovered that it did not enhance their work and might even be detrimental. (Ali, Mohammed, Shamsan, and Hezam, 2023) This worry may result in unequal access to ChatGPT's advantages; specifically, individuals lacking the requisite skills might not be able to fully utilize it, which could lead to disparities in educational opportunities and outcomes (Vartiainen & Tedre, 2023). Thus, professional development programs that give educators and pre-service educators a foundational understanding of AI should be made available to them (Valtonen & Mäkinen, 2022).

- **Using plagiarism detection software**: Utilize plagiarism detection software, which finds similarities between student work and other sources to help spot instances of cheating (Day, 2023).

- **Referencing and verifying information in constructed responses:** By carrying out more research and referencing reliable sources, the data produced by ChatGPT should be confirmed (Day, 2023). Additionally, when citing content produced by ChatGPT, it should be made explicit that the information was produced by an AI language model, along with the date and the platform name, such as "Chat GPT" or "OpenAI's language model" (Kooli, 2023).

- **Monitor student behavior during exams**: Using remote proctoring software that can identify and flag questionable behavior, such as a student accessing outside resources or copying information from other students, teachers can keep an eye on how their students behave during exams (Khan, Ahmad, Jabeur, & Mahdi, 2021).

- **Clear expectations and consequences**: Clear expectations regarding academic integrity and cheating should be established, along with specific penalties for infractions, to discourage cheating (Day, 2023).

- **Inform students about ethical behavior:** It is important to educate students about academic integrity and moral conduct (Kooli, 2023). It is also important to emphasize that cheating is not only immoral but also detrimental to the learning process and, eventually, the cheater's academic success (Crawford, Cowling, & Allen, 2023).

- **Addressing ethical concerns**: Strong data privacy and security procedures should be put in place, and ethical issues should be given top priority, to address ethical concerns (Crawford, Cowling, & Allen, 2023). In addition, data protection and privacy laws, as well as legal and regulatory compliance, must be complied with when using AI chatbots that process user data (Ray, 2023).

- **Attention to Ethical Use**: Users should use ChatGPT ethically, avoiding harmful or unethical uses, such as spreading fake news or engaging in malicious activities (Crawford, Cowling, & Allen, 2023).

With more sophisticated generative AI, like ChatGTP-5, anticipated to arrive soon, these different approaches might be effective for a while but might not hold up over time (Lu, 2019). Rather, we must begin to acknowledge the quickly evolving landscape of educational practices and adapt them to our existing methods (Aktay, Gök, & Uzunoğlu, 2023). In order to optimize ChatGPT's advantages and minimize its disadvantages, it is crucial to use it as a tool rather than a final information source, supplementing its use with human supervision and direction, particularly in urgent circumstances (Vartiainen & Tedre, 2023).

Conclusion

The advantages and disadvantages of GPT should be considered when determining whether and how to use ChatGPT in the classroom (Adıgüzel, Kaya, & Cansu, 2023). It is important for researchers, educators, students, and other professionals to exercise caution when using ChatGPT (AlAfnan, Dishari, Jovic, & Lomidze, 2023). No matter how strong the tool is, it is crucial to keep in mind that ChatGPT cannot take the place of human instructors and trainers; rather, it should be used in conjunction with human assistance and training (Kolchenko, 2018). Accordingly, incorporating ChatGPT into the classroom and instructing students on its safe and productive use can equip them for success in an artificial intelligence-dominated workplace (Albadarin, Tukiainen, Saqr, & Pope, 2023). In this regard, there are a few issues that need to be addressed when instructing Chat GPT (Baidoo-Anu & Ansah, 2023);

- How can ChatGPT be used to enhance students' learning?

- Is it required that educators and learners receive instruction on ChatGPT?

- How should the ChatGPT model be integrated into teacher education programs?

- How do students evaluate ChatGPT?

Policymakers, researchers, educators, and technologists should collaborate to address these issues and start conversations about how technology can be used in a safe and beneficial way to enhance student learning (Mhlanga, 2023). Furthermore, having these conversations is a crucial step in maximizing advantages and guaranteeing academic integrity for teachers and students alike (Ali, Shamsan, Hezam, & Mohammed, 2023). The effectiveness of ChatGPT's integration into the educational process and its ability to improve student learning and achievement will determine its use in the classroom (Aktay, Gök, & Uzunoğlu, 2023). Therefore, ChatGPT's potential to revolutionize education and empower the next generation of learners should be unlocked by taking a careful and balanced approach to its use (Adıgüzel, Kaya, & Cansu, 2023). Through organized training and the provision of sufficient background information, this involves teaching educators and learners how to use it sensibly and recognize its limitations (Bozic & Poola, 2023).

To develop innovative, well-organized, and captivating teaching methods, educators must become highly proficient in integrating ChatGPT into their classrooms (Rasul et al., 2023). To guarantee that they can use ChatGPT in an equitable and efficient manner, educators should be provided with training, assistance, and competency development (Fuchs, 2023). Learners should receive the required training, which includes background knowledge on how to use the information effectively, how this model operates, the data used in their training and how to understand its limitations, challenges, and issues, as well as the ability to evaluate the information it produces, since the inputs determine the accuracy and quality of the information provided (Williamson & Eynon, 2020). Additionally, there should be a focus on reconsidering, refining, and redesigning creative evaluation techniques that give top priority to evaluating students' capacity to apply knowledge to challenging situations and exhibit comprehension (Crawford, Cowling, & Allen, 2023). The creation of precise rules, regulations, and instructional guidelines is an essential remedy in this situation (Jeon & Lee, 2023). Therefore, in order for students to understand the limitations of ChatGPT and the significance of higher-order thinking skills that machines cannot replicate; educational research should offer suggestions for classroom practice (Castañeda & Selwyn, 2018). To fully comprehend ChatGPT and assess its possible advantages, disadvantages, and educational limitations, more research is required. A thorough literature review will offer important new information on the subject. (Vartiainen & Tedre, 2023).

In the literatüre review, ChatGPT has been used in medical education (Eggmann, Weiger, Zitzmann, & Blatz, 2023), language teaching (Lin & Chang, 2020), mathematics teaching (Kabiljagić, Wachtler, Ebner, & Ebner, 2022), social studies teaching (Son, 2020), and education in general (Lo, 2023). In science education, according to the 5E learning model, both middle school students

(Ergun, 2023) and pre-service teachers (Okul & Muslu, 2024) were used in lesson plan design and in learning the views of middle school students on recycling (Aktay, Gök, & Uzunoğlu, 2023), (Çelik, 2023), motivation to learn chemistry (Korsakova, et al., 2021), and measuring the capacity to answer, explain and solve chemistry-related questions and problems (Clark, 2023). These studies have demonstrated the potential for additional advancement in this emerging field and the necessity for more thorough investigation into the various educational applications of ChatGPT.

Acknowledgement and Notes:

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