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COMMENTARY

The Widespread Application of Artificial Intelligence in Education Necessitates Critical Analyses

Xiaoqiao Cheng

Nanjing Normal University, Nanjing 210024, Jiangsu, China

"Success in creating AI would be the biggest event in human history. Unfortunately, it might also be the last, unless we learn how to avoid the risks." –Stephen Hawking

ARTIFICIAL intelligence (AI) is a wide-ranging branch of computer science concerned with the development of computer systems and smart machines capable of performing tasks that typically require human intelligence such as learning, problem-solving, and decision-making. AI technology can serve as an extension of human intelligence, carrying out part of the work that could only be done by humans in the past and even tasks that humans are incapable of accomplishing, which can potentially elevate social productivity to a significant extent. To date, AI has permeated every aspect of our life. Education is one of the spheres to which AI will bring profound changes.

UNESCO' working paper "*Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development*" gives a thorough evaluation of the extent to which AI affects the education sector (Pedro et al., 2019). AI holds tremendous promise as a tool to empower the educational actors. For instance, learning analytics can promote personalized education by providing diagnoses of the individual student's learning status, giving prompt feedback, and tailoring learning materials; educational data mining can be employed to analyze data gathered during teaching and learning to enable more efficient and effective educational management and more informed decision-making (Shan & Zhao, 2019). On the other hand, as with other information technologies, AI also imposes a variety of risks to educational development. As a data-driven technology, AI's application in education necessarily involves immense volumes of educational data. As a result, it is imperative to research into AI's existing and potential threats to relevant stakeholders', particularly students', privacy and other human rights.

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Ethics of Artificial Intelligence in Education: Student Privacy and Data Protection in this issue examined the challenges that AI technology poses on student data privacy protection and proposed strategies for addressing concerns regarding student personal information security, including optimizing the regulation of personal data usage, heightening students' awareness of personal data protection, providing students with legal remedies against infringement of data privacy, and improving IT industry self-regulatory mechanisms (Huang, 2023). It is hoped that this study will inspire more critical analyses on the ethical risks of educational application of artificial intelligence.

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ORIGINAL ARTICLE

Turkish Pre-service Teachers' Understanding of Daily Life Phenomena Related to Chemistry and Compatibility with the Current Chemistry Curriculum

Oya Aglarci Ozdemir

Marmara University, Istanbul, Turkey

Abstract*: The aim of this study is to determine Turkish pre-service science teachers' levels of chemical explanations of various daily life phenomena and to investigate whether these examples are in accordance with the high school chemistry curriculum in Turkey. This study was carried out with descriptive research methods. The participants are 71 freshmen pre-service science teachers in a state university in Turkey. The data of the study were collected with the "Chemical Explanations of Daily Phenomena" Questionnaire previously developed in the literature. The phenomena in the questionnaire were related to chemistry concepts such as diffusion, temperature, combustion reactions and the law of conservation of mass, isotopes, reaction rate, redox reactions, and mixtures and solutions. The answers were analyzed in three categories: correct, wrong, and can't determine and the frequencies and percentages of the categories were determined. Also, the learning outcomes in the latest version of the Turkish high school chemistry curriculum were examined in order to determine whether they were related to the chemistry concepts in the questionnaire. Document analysis was utilized to analyze the learning outcomes in the chemistry curriculum. The findings of the study revealed that most of the pre-service teachers answered correctly the questions that are compatible with the chemistry curriculum. Their misconceptions were mostly related to heat transfer and specific heat capacity, the law of conservation of mass, and heavy water and isotopes. The findings indicated that future curriculum changes should integrate some important chemistry concepts closely related to everyday life, such as radioactivity and heat transfer.*

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Keywords: *Chemical Literacy, Misconceptions in Chemistry, Pre-Service Teachers, Chemistry Curriculum*

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Introduction

THE modern world is changing rapidly with the developments in science and technology. People are expected to adapt quickly to the changing world and to understand the impact of developments in science and technology. Science education is one of the ways to achieve and facilitate this adaptation and offers ways for understanding science and technology. The major aim of science education is scientific literacy. Science educators and science education documents have proposed different definitions and important aspects of scientific literacy (e.g. Bybee, 2012; National Research Council [NRC], 1996; Norris & Phillips, 2003; Roberts, 2007). According to Holbrook and Rannikmae (2009), scientific literacy is closely related to an appreciation of the nature of science, and the development of social values and personal attributes. Scientific literacy is not just for those who aim for a career in Science Technology Engineering Mathematics (STEM) areas, but for all students (Suwono et al., 2017). Bybee (1997) has proposed a framework in which scientific literacy can be examined at four levels (components) for school science education. Those are:

1. Nominal literacy: Students can recognize important scientific terms and concepts, but do not know the meaning of that term/concept and/or have misconceptions about them. For example, students have heard of atoms, cells etc., but they might think atoms are the smallest living organism because cells consist of atoms (Papageorgiou et al., 2016).
2. Functional literacy: Students can use scientific and technological terms and concepts, but they usually have a limited understanding and/or they cannot explain them in their own words. For example, students can speak about melting and dissolving in chemistry lessons, but they cannot fully explain the difference between them.
3. Conceptual literacy: They understand scientific concepts and their relationship with daily lives. For example, they can understand the relationship between force and motion as well as the daily life applications of fundamental laws of physics.
4. Multidimensional literacy: Students understand scientific concepts and phenomena. Also, they can understand various perspectives such as philosophical, historical, ethical, and economic in science and socioscientific issues that are embedded in science-technology- society interactions. For example, students understand what causes global climate change and the effects of global climate change on the environment, human health, and economy.

Scientific literacy includes scientific concepts, phenomena, and ideas from various scientific disciplines and these different levels of scientific literacy suggest that each discipline may have its own specific literacy. Thus, the major aspects of scientific literacy related to different scientific disciplines are very varied (Shwartz et al., 2006). Understanding and investigating the unique nature and characteristics of each discipline will contribute to scientific literacy specific to that field (e.g. biology literacy, chemical literacy, health literacy, etc.) and scientific literacy in general.

There is always a transformation and change in natural phenomena, and whether the phenomena are observable or not, they are related to the chemical reactions. Chemistry involves studying matter and understanding the properties and components of matter that are important in disciplines such as physics, geography, health sciences, and environmental science (Petrucci et al., 2010). The Earth and its surroundings are involved with chemical components and products (Gilbert & Treagust, 2009). A scientific and practical understanding of chemistry can help students to understand the world that they are a part of. Chemistry includes observable (with the senses or the extension of senses-macroscopic level) and submicroscopic properties of matter as well as symbolic representations (Johnstone, 1991) which could be considered as a unique language related to the field. Chemical knowledge and explanations are needed for an understanding of daily life experiences (e.g. cleaning, cooking, and functioning of biological systems) as well as consideration and resolution of global issues (e.g. health issues, energy issues, environmental issues). Students' understanding of chemistry in their daily lives is essential in order to enhance meaningful science teaching (Yadigaroglu et al., 2021). School students should acknowledge the important role of chemistry in their lives as well as appreciate the discipline for their future well-being to have a good quality in their lives.

There are different definitions of chemical literacy stemming from various studies and theoretical frameworks since the 1980s (e.g. Bond, 1989; Cigdemoğlu & Geban, 2015; Shwartz et al., 2006; Kohen et al., 2020; Witte & Beers, 2003). Students' understanding of chemistry and their ability to use chemistry understanding in daily life is referred to as chemical literacy (Tsaparlis, 2000). Witte and Beers (2003) define chemical literacy as students' ability to use the information and scientific knowledge related to a chemical issue/problem and deal with the information to understand daily life problems. Chemical literacy helps students to understand and interpret ideas or discussions about chemistry and use these skills in their decision-making processes (Hofstein et al., 2011; Kohen et al., 2020).

Chemical literacy is an important part of scientific literacy (Mozeika & Bilbokaite, 2010) and comprised of three components: (1) key concepts in fundamental chemistry (such as compounds, elements, element symbols, chemical processes, and atomic models) (2) understanding what chemists and scientist do and what their scientific research is about, and (3) social context-understanding chemistry in real-life related issues (Dori et al., 2018; Shwartz et al., 2013). Shwartz et al. (2006) also mentioned the affective aspect, which refers to having an interest in chemistry-related issues. For example, students' curiosity about the chemicals in cleaning materials, learning about their properties, and using the knowledge when choosing cleaning products can be given as an example of the affective aspect. However, some chemistry teachers might tend to emphasize teaching scientific knowledge, rather than the skills and information that help students to understand the importance of chemistry in daily life. Also, students might think that chemistry concepts and theories are very difficult to learn and/or they have little value for their future professions and lives (Cigdemoglu & Geban, 2015). High school students find chemistry to be an intriguing subject because it mostly deals with abstract ideas that go beyond human experience and observation, making these things less intuitive (Cooper & Stowe, 2018). One of the main reasons for these problems in Turkey may be that mostly theoretical knowledge is included in the chemistry curriculum and great importance is attached to the teaching of this knowledge (Özden, 2007) and therefore chemistry education programs emphasize traditional and theoretical knowledge rather than associating this knowledge with daily life. A holistic understanding of chemistry plays an important role in individual and societal decision-making on chemistry-related issues and researchers have argued that both students and the public should achieve chemical literacy (Avargil et al., 2013; Dori et al., 2018). In this respect, it is important to determine the chemistry literacy levels of the students and consider their compatibility with the outcomes in the high school chemistry curriculum.

The definition of CL given by Shwartz et al. (2006) was based on a consensus view among chemists, educators, and high school teachers. The definition is based on the scientific literacy framework proposed by Bybee (1997), and there are four domains (components) of chemical literacy that high school graduates (freshmen university students) are expected to be familiar with (Shwartz et al., 2006).

Chemistry content knowledge: Students can understand general chemical facts, ideas, scientific research, generalization, and how to relate chemistry knowledge with other disciplines to find answers to scientific questions. Also, students should understand multiple representations in chemistry (macroscopic, sub-microscopic, and symbolic levels).

Chemistry in context: Students can use chemistry knowledge in order to explain daily life issues and make scientific and evidence-based decisions, and join in public debates about chemistry-related issues.

Higher-order thinking skills in chemistry: Students can ask questions about what observe or experience and also collect data, make inferences, and evaluate the multiple natures of the debates.

Affective aspects related to chemistry: Students can show interest in chemistry and chemistry-related issues in formal (chemistry education in school) and non-formal learning areas (e.g. social media, and news).

Various studies have been conducted to assess the chemistry literacy levels of students in chemistry education (Celik, 2014; Sadhu & Laksono, 2018; Shwartz et al., 2006; Thummathong & Thathong, 2016; Witte & Beers, 2003). Shwartz et al. (2006) investigated the chemical literacy levels of 10th-12th grade chemistry students. They aimed to assess students' ability to recognize chemical concepts (nominal literacy), describe key concepts in chemistry (functional literacy), and use chemistry understanding to explain everyday phenomena (conceptual literacy); and read materials (articles, advertisements, internet sources) and analyze information about chemistry given in the text (multi-dimensional literacy). They found that fundamental chemistry courses mostly contributed to nominal chemical literacy whereas only a small percentage of students achieved functional chemical literacy (the ability to define a concept correctly). Also, the majority of students did not give correct scientific explanations of daily phenomena. Using the same assessment tool, Celik (2014) determined Turkish pre-service teachers' levels of chemical literacy. The results showed that most students could relate their scientific understanding of chemical reactions, oxidation, diffusion, and mixtures to their daily lives. However, most of the students could not define chemistry concepts which were a sign of their low levels of functional chemical literacy.

Many countries aim to promote scientific literacy (e.g. England, Canada, Norway, the USA, Taiwan, and Australia) and chemistry curricula have been changed, in keeping with reforms of the other science content curricula in many countries to achieve the aim of chemical literacy (Herscovitz et al., 2012). The importance of scientific literacy as an aim of science education has been underlined in the last 20 years in Turkey. The aim of Turkish science teaching programs is to improve students' scientific literacy (Ministry of National Education of Turkey [MNE], 2013; 2018). Turkey is one of the countries which undergo major changes in education programs from time to time. Various revisions have been made in primary and secondary school programs to emphasize the relationship of knowledge with technology and society, as well as scientific concepts and content knowledge. The main goal of the new chemistry curriculum is to educate people to be chemically literate. In this context, the high school chemistry education curriculum helps students

- To have knowledge about the basic principles, concepts, theories, models, and laws of chemistry;
- To use chemistry knowledge and skills they have acquired course in explaining the phenomena related to daily life, environment, health, and industry;
- To understand and comprehend the role of chemistry in the continuity of life (mne, 2018).

Science teacher education programs focus on the development of literacy skills of pre-service teachers in discipline-specific areas (e.g. chemical literacy, health literacy, etc.). In particular, their ability to understand and explain current daily phenomena with theoretical chemistry knowledge (chemical explanations of everyday phenomena) will significantly affect the chemical literacy levels of their prospective students in the future to fulfil the aim of scientific literacy. In addition, the chemical explanations of first-year university students about daily phenomena mostly reflect their high school chemistry knowledge (Celik, 2014). In this direction, the examination of how chemistry concepts are included in the high curriculum is important in terms of explaining and making sense of the chemistry understanding of first-year students. Therefore, the aim of the present study is to determine freshmen pre-service science teachers' levels of chemical explanations of daily life phenomena. Also, it is aimed to investigate whether these examples are in accordance with the high school chemistry curriculum in Turkey. In light of this aim, the research questions are:

- How is pre-service science teachers' understanding of chemistry related to daily life phenomena?
- How are chemistry concepts in daily life phenomena included in the high school chemistry curriculum?

Materials and Method

This study was carried out with descriptive research methods. The descriptive design was used to examine and understand the phenomenon by getting information directly from the pre-service teachers involved in the teacher education program (Merriam, 1998). The study group was determined according to the convenience sampling method, one of the qualitative research sampling methods, and non-probability sampling (Patton, 2015). This sampling method allows the researchers to conduct the study practically since it is a type of non-probability sampling method (Yıldırım & Şimşek, 2013).

The participants of the study were 71 pre-service science teachers including 64 females and 7 males. They were freshmen students at the Department of Science Education in a state university in Turkey. In their first year of education, freshmen students usually take General Chemistry I-II and Chemistry Laboratory I-II courses as well as Biology and Physics courses. The data of the study were collected while the pre-service teachers were still taking their first semester courses (at the beginning of their first semester). Their ages were between 18-19 years and they all volunteered to be participants to join the study.

Data Collection

The data of the study were collected with a Multiple-choice Questionnaire titled as the "Chemical Explanations of Daily Phenomena" Questionnaire developed by Shwartz et al. (2006). The original questionnaire was translated into Turkish and used in another study for investigating Turkish pre-service teachers' chemical literacy levels (Celik, 2014). The questionnaire aimed to assess students' chemical explanations about daily life/everyday phenomena (e.g. rusty nail/redox reactions, smelling perfume/diffusion of gases). This questionnaire aims to determine the levels of conceptual chemical literacy. A number of examples from daily life and some statements about these examples were given in the questionnaire. The pre-service teachers were asked to carefully read the statements and decide whether the statements about the given phenomena were correct or incorrect. If they don't know the answer, there was a third option; "I can't know how to determine". There were 11 different everyday phenomena in the original questionnaire consisting of two different versions (version A and version B). 7 of these phenomena were used for the current study. Since only 5 scenarios were used in the translated version of Celik's study (2014), 2 of the scenarios were translated into Turkish by the researcher. The final version of the questionnaire in Turkish was examined by an outside researcher who is an expert in the field of science and chemistry education. These phenomena were related to chemistry concepts below:

- Diffusion of gases: smelling a perfume;
- Heat and temperature: wooden chair and metal chair;
- Combustion reactions and the law of conservation of mass: burning of a candle;
- Isotopes: heavy water;
- Reaction rate: acid rain;
- Redox reactions: rusting of iron;
- Mixtures and solutions: oil and water.

In line with the purpose of the study, the researcher investigated how these phenomena in the questionnaire are included in the chemistry curriculum. For this reason, the learning outcomes in the high school chemistry curriculum were examined. The latest version of the chemistry curriculum was revised and renewed in 2018 (MNE, 2018). According to the suggestions and demands of chemistry teachers and different stakeholders, some chemistry concepts and theories have been excluded from the curriculum; therefore the curriculum has been simplified compared to the earlier version. In addition, the learning outcomes were restructured to reflect higher-order thinking skills and daily life examples (Elmas et al., 2020). The learning outcomes in the curriculum were examined whether the daily phenomena and chemical concepts in the questionnaire are included (whether they are related to the chemistry topics in the questionnaire). If the statements in the questionnaire are not emphasized by the learning outcomes, students probably will not be

Table 1. Keywords Used for Search in the High School Chemistry Curriculum (MNE, 2018).

Daily Life Phenomenon	Keywords (searching words for curriculum)
Diffusion (Gases)	Diffusion, gas (gases), smell, smelling, perfume, odor
Temperature	Temperature, heat transfer, specific heat capacity
Combustion reactions (Burning candle)	Candle, wax, combustion reaction(s), the law of conservation of mass (conservation of mass)
Isotopes (Heavy water)	Heavy water, isotope(s), deuterium, radioactivity
Limestone reacting with acid	Limestone, acid(s), reaction rate, acid reaction (alternative keyword: acid-base reactions)
Redox reactions (Rusty nail)	Redox reaction, oxidation, nail, chemical bond, iron
Water and oil mixture	Mixture, heterogeneous mixture, oil-water (water-oil), hydrophobic

able to answer these statements correctly or they can probably only give answers based on guesses and interpretations of other knowledge sources. In the study, the aim was specifically to address this issue.

Data Analysis

The answers given by the pre-service teachers to each statement in the "Chemical Explanations of Daily Phenomena" Questionnaire were analyzed in three categories: correct answer, wrong answer and don't know/can't determine. The responses of the pre-service teachers to each statement in the questionnaire were analyzed by the researcher. The frequencies and percentages of the data obtained from the questionnaire were determined and presented in tables.

Also, document analysis was utilized and the learning outcomes in the chemistry curriculum were examined to answer the second research question. There are five steps to follow in document analysis "(1) accessing the relevant documents, (2) checking the authenticity of documents (accessing through official sources), (3) understanding documents (analyzing documents in a certain system and comparatively with each other), (4) analyzing data, and (5) using data to illustrate what the document refers to". In this study, five steps suggested by Yıldırım and Şimşek (2013) were followed to perform the analysis. The researcher first accessed the current chemistry curriculum (Secondary Education Chemistry Curriculum (MNE, 2018) via the official web page of MNE. This procedure is the first two steps in document analysis. For the third step, the researcher analyzed the learning outcomes which are related to the daily life examples in the questionnaire. For example, the first question is about the diffusion of gases, and the researcher searched for learning outcomes with the keywords such as gases, gas, diffusion, and smelling. The keywords searched in the curriculum within the scope of each question and statements in the questionnaire are presented in **Table 1**. Once the learning outcomes with these keywords were identified, they were examined for their correspondence with each statement in the daily life phenomena. Finally, the learning outcomes associated with each phenomenon are presented with direct quotations and/or examples. If a statement in the phenomena is not related to learning outcomes, this is also explained. This analysis was conducted by the researcher at two different times. After that, the outcomes were also examined by an expert chemistry teacher with a master's degree and a university professor in the science education department. All of the experts and the researcher reached a consensus on the analysis.

Results

In this section, the findings showing the chemical literacy levels of pre-service science teachers' chemistry knowledge of daily life phenomena are presented, and then the inclusion of chemistry concepts in daily life phenomena in the high school chemistry curriculum is examined. The findings are presented under seven sub-headings related to the daily life phenomena in the questionnaire. Each of these subheadings (Daily Life Phenomenon …) is presented in ***bold italics*** type. The quotations of the learning outcomes are given in italics type in the text.

Pre-service teachers' levels of conceptual chemical literacy were determined with questions asking about daily life-related phenomena. For each phenomenon, there were some statements that were evaluated as a correct or incorrect statement. For a third option, if the pre-service teachers didn't understand the statement nor had no knowledge about it, then they could choose to answer as "I can't determine/don't know. Scientifically correct statements are shown in normal font, and the incorrect statements are written in italic font in the following tables. Frequency (f) and percentage (%) values of each category are presented in the relevant tables.

Daily Life Phenomenon 1: Diffusion

Pre-service science teachers' conceptual understandings of diffusion are presented in **Table 2**. In this question, Statements 1A, 1C, 1D, and 1E (written in normal font) are the correct statements), whereas 1B and 1F (written in italics) are incorrect. The pre-service teachers mostly had a correct understanding of diffusion in statements 1A, 1C, and 1D. However, 39.44% of the participants had a misconception about the relationship between boiling point and evaporation (Statement 1B). Half of the participants answered statement 1E about smelling correct. However, as can be seen from the other

Table 2. Pre-Service Teachers' Conceptual Understanding of Diffusion.

"When a bottle of perfume is left open in a room - after a while, people can smell the perfume across the room. Below there are several statements pertaining to this phenomenon."

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
1A	Some of the perfume molecules pass from a fluid aggregate state to a gaseous aggregate state.	69	97.18%	2	2.82%	-	-
1B	*Transition to the gaseous state will take place only if the boiling point of the perfume is lower than the temperature of the room.*	28	39.44%	27	38.02%	16	22.53%
1C	The perfume molecules spread throughout the room through clashing with other molecules in the air.	68	95.77%	3	4.23%	-	-
1D	The higher the temperature in the room becomes the faster will be the evaporation.	58	81.69%	8	11.27%	5	7.04%
1E	A weak chemical bond forms between the perfume molecules and special sensors found in our noses.	36	50.70%	15	21.13%	20	28.17%
1F	*The connection between the perfume molecules and the smell sensors in the nose is not a chemical connection but rather a biological connection.*	41	57.75%	13	18.31%	17	23.94%

related statement 1F, most of the pre-service teachers did not fully grasp the chemistry of smell. Smelling odor is a chemical process but 57.75% of them thought that it is a biological process.

Diffusion in the chemistry curriculum: Diffusion is a key concept in the "Gases" unit at the Grade 11 level. In the chapter, there are two learning outcomes related to the derivation of Graham's Diffusion law and an experiment on the diffusion of gases as seen below:

"The Graham Law of Diffusion and Effusion is derived using the basic assumptions of kinetic theory." L.O. 11.2.3.1.b

"Diffusion experiment is performed; explained by using information technologies (animation, simulation, video, etc.)." L.O. 11.2.3.1.c

In addition to this, in the Gases unit, there is a learning outcome related to establishing a daily life relationship (e.g. "*Explains the partial pressures of gas mixtures with examples from daily life"-L.O. 11.2.4.1. Grade level 11*), however, the outcome is not related to the concept of diffusion. Also, the learning outcomes that may be related to the question in the questionnaire were searched with different keywords such as smell, smelling, and perfume. There are no outcomes related to smell and the process of smelling.

Table 3. Pre-Service Teachers' Conceptual Understanding of Temperature.

"A wooden chair and a metal chair are held in the same room for an extended period. Then, the temperatures of both chairs are measured. There are different statements below related to the temperature of the metal chair and the wooden chair."

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
2A	Transfer of energy will take place between the particles/molecules of each chair and the molecules in the air in the room to the point of equilibrium of energy between the air in the room and the chairs.	44	61.97%	20	28.17%	7	9.86%
2B	Transfer of energy will take place between the particles/molecules of each chair and the molecules in the air in the room to the point of equilibrium of temperatures between the room and the chairs.	54	76.06%	10	14.08%	7	9.86%
2C	When equilibrium in temperature between the two chairs in the room is reached - the particles building the two chairs will have the same kinetic energy as the molecules in the air.	28	39.44%	29	40.85%	14	19.72%
2D	*There will be a difference in temperatures of the two chairs. The metal one will heat up more if the room is hot and will cool off more if the room is cold.*	50	70.42%	15	21.13%	6	8.45%
2E	*The proof that the temperature of the two chairs is different is how we feel when we sit on them.*	26	36.62%	31	43.66%	14	19.72%
2F	*The final temperature of each chair depends on the melting point of the material it is built of.*	22	30.99%	32	45.07%	17	23.94%

In addition, the learning outcome related to perfume only includes an explanation of the harmful chemicals it may contain (grade level 10) which is not related to diffusion. In this respect, it can be said that students do not have curricular chemistry knowledge that may enable them to answer the questions in 1E and 1F.

Daily Life Phenomenon 2: Temperature

Pre-service science teachers' understanding of temperature is presented in **Table 3**. Most of the pre-service teachers gave correct answers for statements 2A and 2B (61.97%-76.06%). However, it is seen that they had various misconceptions in many of the other statements, especially in 2D. 70.42% of them thought that the metal chair would more heat up than the wooden chair in a hot environment, or cool off more in a cold environment, incorrectly. The most important misconception seen in this section is that they think that different substances made of different materials in the same environment (waiting for a while) can have different temperatures. This might show that their understanding of heat transfer is problematic and/or they don't take into account the specific heat capacity of the material that the chair is made of.

Table 4. Pre-Service Teachers' Conceptions of Burning Candle.

"When a candle burns it seems that the wax (wax is a solid mixture of carbohydrates) disappears. Following are various statements explaining what happens to wax when the candle burns/burning the candle."

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
3A	*In the course of burning the volume of the wax lessens mainly because air trapped within the wax during its production is released.*	41	57.75%	9	12.68%	21	29.58%
3B	*A candle burning is just only a change in the state of aggregation of the wax that the candle is made of - first it melts and after it evaporates.*	45	63.38%	22	30.99%	4	5.63%
3C	The burning of a candle is a reaction between the wax and oxygen in the air.	61	85.92%	6	8.45%	4	5.63%
3D	*The law of conservation of mass exists in states of combustion reaction only if it occurs in a closed vessel.*	48	67.61%	11	15.49%	12	16.90%
3E	*The law of conservation of mass exists in states of combustion reaction only if complete combustion takes place.*	24	33.80%	30	42.25%	17	23.94%

Temperature in the chemistry curriculum: The concept of temperature is covered in the high school chemistry curriculum within the scope of different topics such as gases, liquids and viscosity, solubility, and reaction rate. However, the statements in the questionnaire ask about the role of temperature in heat transfer. For this reason, after searching with temperature as a keyword, keywords such as heat transfer, and specific heat capacity were investigated in the curriculum. However, it is seen that these topics are not addressed in the high school chemistry curriculum. Although it is not included in the scope of the study, it was determined that the content related to this phenomenon in the questionnaire was actually covered in the high school physics curriculum.

Daily Life Phenomenon 3: Burning Candle

Pre-service science teachers' understanding of burning candle is presented in **Table 4**. The question on the burning of candle was aimed at identifying participants' conceptual understandings of combustion reactions and also the law of conservation of mass. Even though most of the students (85.92%) had a correct understanding of the reaction between the wax and oxygen (statement 3C), most of them had a misunderstanding about the chemical reaction of the wax (3A). 57.75% of the pre-service teachers incorrectly thought that there was air trapped in the wax and it was released during burning. In addition, there are some important misconceptions about the law of conservation of mass. Most of the pre-service teachers (67.61%) thought that conservation of mass can only occur in a closed vessel. Similarly, some students (33.80%) also thought that *"The law of conservation of mass exists in states of combustion reaction only if complete combustion takes place" which is an incorrect statement.*

Burning of Candle in the Chemistry Curriculum: Keywords related to the phenomenon such as candle, wax, combustion reaction(s), and the law of conservation of mass were searched in the chemistry curriculum. Among the learning outcomes related to candles and wax, there is a learning outcome on esters at the 12*th*-grade level: "*Wax is given as an example of natural substances containing esters- L.O. 12.3.7.1. Grade level 12*". However, this learning outcome does not contain any related information about combustion reactions. Among the learning outcomes related to the law of conservation of mass is the following excerpt in the "*Fundamental Laws of Chemistry and Chemical Calculations*" unit at the 10th-grade level. In this outcome, the relationship with daily life is not emphasized.

"Explains the basic laws of chemistry and makes calculations about conservation of mass" (L.O. 10.1.1.a)

The learning outcomes related to combustion reactions are included in the unit of "*Fundamental Laws of Chemistry and Chemical Calculations*" at the Grade 10 level. Combustion reactions are key concepts in this unit. The learning outcome in this unit is given in the following excerpt below. Although it is stated in the learning outcome that combustion reactions will be explained with various examples, the relevance of these examples to daily life is not specified.

"Combustion, synthesis (formation), analysis (decomposition), acid-base, dissolution-precipitation reactions are explained with examples." L.O. 10.1.3.1.b

Daily Life Phenomenon 4: Isotopes

Pre-service science teachers' understanding of heavy water and isotopes is presented in **Table 5**. The majority of the pre-service teachers could not give correct answers to the statements in this question. Most of the pre-service teachers were able to give a correct answer only to statement 4E (57.75%). Also, in this section, some of the pre-service teachers (29.58%-36.62%) stated that they did not know the answer.

Isotopes in the chemistry curriculum: The learning outcomes were searched with keywords such as heavy water, deuterium and isotope, and radioactivity. It is seen that there is no content or learning outcome related to heavy water, deuterium, and radioactivity in the high school chemistry cur-

Table 5. Pre-Service Teachers' Conceptual Understanding of Isotopes.

"You will certainly have heard the term heavy water somewhere. What kind of water is this? What differences would you expect to find between regular water and 'heavy water?"

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
4A	*Heavy water is distilled water.*	30	42.25%	18	25.35%	23	32.39%
4B	*Heavy water is water in which the molecules contain only hydrogen, e.g., deuterium.*	32	45.07%	13	18.31%	26	36.62%
4C	*The difference between a regular hydrogen atom and a deuterium atom is in the number of protons in the nucleus.*	34	47.89%	16	22.53%	21	29.58%
4D	*Water molecules containing heavy isotopes cannot be found in nature.*	19	26.76%	26	36.62%	26	36.62%
4E	*There is no difference in density between 'regular' water and 'heavy' water.*	8	11.27%	41	57.75%	22	30.99%

Table 6. Pre-service teachers' conceptual understanding of limestone reacting with acid.

"To examine the effect of acid rain on buildings and sculptures built of limestone the following experiments were conducted: In the first experiment a small block of limestone rock whose mass was 1 gram was put into an acid solution. The block reacted (to the point of its complete disappearance) and gas was discharged, was collected and its amount was measured precisely. In the second experiment 1 gram of limestone dust was put into an identical amount and identical concentration of acid. Both experiments were carried out at exactly the same temperature. Following are various statements pertaining to the two experiments:"

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
5A	*The solid limestone changed aggregation state; in the course of the reaction it turned into liquid and after to gas.*	34	47.89%	25	35.21%	12	16.90%
5B	*Only the temperature influences the rate of reaction.*	12	16.90%	56	78.87%	3	4.23%
5C	*Since the identical temperature was maintained in both the experiments - the reaction occurred at exactly the same rate.*	17	23.94%	50	70.42%	4	5.63%
5D	Exactly the same volume of gas was obtained in the two experiments.	52	73.24%	10	14.08%	9	12.68%
5E	The gas discharged in the reaction is carbon-dioxide.	61	85.92%	3	4.23%	7	9.86%
5F	The reaction was faster in the second experiment because of a larger interface between the acid and the limestone.	55	77.46%	13	18.31%	3	4.23%
5G	A change in the acid concentration could also change the reaction rate.	66	92.96%	5	7.04%	-	-

riculum. However, the concept of an isotope is included as a key concept in "the Atom and Periodic System" unit at the 9th-grade level and there is a learning outcome about isotopes in the unit as shown below:

"The concepts of the electron, proton, neutron, atomic number, mass number, isotope, isotone, isobar, and isoelectronics are introduced." L.O. 9.2.2.1.a

However, the relationship with daily life (such as heavy water and isotopes) is not covered in the curriculum. In addition, at the Grade 10 level, the concept of isotope and the reason why the molar masses of some elements are not integers are explained in the unit; "Fundamental Laws of Chemistry and Chemical Calculations" (L.O. 10.1.2.1.c).

Daily Life Phenomenon 5: Limestone Reacting with Acid

Pre-service science teachers' conceptual understanding of "limestone reacting with acid" is presented in **Table 6**. Most of the pre-service teachers answered the statements given in this daily life phenomenon correctly (5B, 5C, 5D, 5E, 5F, 5G). The percentages of those who answered the questions correctly ranged between 70.42% and 92.96% except for one item; 5A. Only 35.21% of the pre-service teachers were able to answer item 5A correctly whereas 47.89% answered incorrectly.

The phenomenon "Limestone reacting with acid" in the chemistry curriculum: The learning outcomes were searched with limestone, acid, reaction rate, and acidic reactions. The Unit; "Reaction Rates" is at the 11th-grade level and "the Factors Affecting the Rate of Reaction (e.g. temperature, particle size)" are explained among the outcomes. The relevant outcome is given in the excerpt below:

"Explains the factors affecting the reaction rate. The effect of substance type, concentration, temperature, catalyst (not enzymes), and contact surface on the reaction rate is emphasized." L. O. 11.5.2.1

The learning outcomes related to acidic reactions are included in the unit "the Fundamental Laws of Chemistry and Chemical Calculations" at the Grade 10 level. The acid reaction is a key concept in this unit. The learning outcome in this unit is given in the following excerpt below:

Table 7. Pre-Service Teachers' Conceptions of Redox Reactions.

"A nail made of iron rusted after being in an environment in which it was exposed both to air and to moisture. The nail looks as if the iron was "eaten" and disappeared, but when weighing the iron and the rust that formed on it, it became clear that the mass was higher than the original mass of the nail, before it rusted. Following are statements relating to this phenomenon:"

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
6A	*The nail's mass increased only because the water molecules that were absorbed on the surface of the metal and molecules of the material are different than the air that was absorbed on the surface of the metal.*	14	19.72%	46	64.79%	11	15.49%
6B	The mass of the nail increased because the iron reacts with the oxygen.	70	98.59%	-	-	1	1.41%
6C	During a reaction between a metal and oxygen, there is a transfer of electrons from the metal to the oxygen.	43	60.56%	12	16.90%	16	22.53%
6D	*During a reaction between metal and oxygen a covalent bond forms between the metal atoms and the oxygen atoms.*	29	40.85%	33	46.48%	9	12.68%
6E	Various metals differ from each other in their tendency to be oxidized.	67	94.37%	-	-	4	5.63%
6F	Iron is a metal that has the highest tendency to be oxidized.	60	84.51%	4	5.63%	7	9.86%

"Combustion, synthesis (formation), analysis (decomposition), acid-base, dissolution-precipitation reactions are explained with examples." L.O. 10.1.3.1.b

In addition, "the Acids, Bases, and Salts" unit in Grade 10 includes detailed learning outcomes related to this phenomenon. Also, daily life example in the questionnaire is included in the curriculum on acids and bases in our lives (L.O. 10.3.3.1). The related learning outcomes are presented in the excerpts:

"Teacher explains important reactions of acids and bases in terms of daily life." L.O. 10.3.2.2.

"Teacher explains the benefits and harms of acids and bases. The formation of acid rain and its effects on the environment and historical artefacts are mentioned." L.O. 10.3.3.1

Daily Life Phenomenon 6: Redox Reactions

Pre-service science teachers' understanding of "rusty nail-reduction-oxidation" is presented in **Table 7**. It is seen that pre-service teachers gave a high percentage of correct answers, especially to statements 6B, 6E, and 6F (84.51%- 94.37%). Similarly, most of the participants gave correct answers to items 6A and 6C. Only about half of them answered the question about the type of chemical bond in 6D correctly.

Redox reactions in the chemistry curriculum: The learning outcomes were searched with redox reaction, oxidation, corrosion, nail, and chemical bond. Redox reactions are included in "the Chemistry and Electricity" unit at the Grade 12 level. In addition, learning outcomes related to the concept of corrosion are also included in the same unit. Within the scope of this unit, students:

"Recognize redox reactions. a. The concepts of oxidation and reduction are emphasized. Redox reactions are equated and common oxidants (O2) and reductants are introduced." L. O. 12.1.1.1
"Explain the electrochemical basis of corrosion prevention methods. a. The concept of corrosion is explained." L.O. 12.1.6.1.

In addition, ionic bonds and covalent bonds are included in detail among the high school chemistry curriculum learning outcomes at the 9^{th}-grade level.

Daily Life Phenomenon 7: Water and Oil Mixtures

Pre-service science teachers' understanding of water and oil mixture is presented in **Table 8**. Most of the pre-service teachers possessed an adequate understanding of this phenomenon. The percentages of correct answers were more than fifty percent for each statement. Statement 7B (*water and oil do not mix because they have different specific gravity*), is the one with the lowest percentage of correct answers in this section (25.35%).

Mixtures in the chemistry curriculum: In order to determine the learning outcomes regarding this phenomenon, the curriculum was searched with the keywords; mixture, heterogeneous mixture, oil-water, water-oil, and hydrophobic. In the 10th-grade level "Mixtures" unit, there are learning outcomes related to heterogeneous mixtures and homogeneous mixtures as can be seen below:

"Student classifies mixtures according to their qualities." L.O. 10.2.1.1.

"Explains the properties that are decisive in distinguishing homogeneous and heterogeneous mixtures." L.O. 10.2.1.1.a

Table 8. Pre-Service Teachers' Conceptions of Water and Oil.

"If we put water and oil in a test tube we will discern that they don't mix with each other. Following are various statements that are related to this phenomenon."

		Correct statement (f-%)		Incorrect statement (f-%)		I can't determine (f-%)	
7A	Water and oil are a mixture	66	92.96%	4	5.63%	1	1.41%
7B	*Water and oil do not mix because the two materials each have a different specific gravity.*	18	25.35%	41	57.75%	12	16.90%
7C	The term hydrophobic relates to material whose molecules do not bond with water molecules	66	92.96%	2	2.82%	3	4.23%
7D	Molecules of hydrophobic material are non-polarized molecules	48	67.60%	12	16.90%	11	15.49%
7E	There are molecules that are capable of bonding with both water molecules and molecules of oily materials.	45	63.38%	9	12.68%	17	23.94%
7F	Most creams for cosmetic use are a uniform mixture of a watery solution and some kind of oily material.	58	81.69%	3	4.23%	10	14.08%

"It is emphasized that homogeneous mixtures are called solutions and examples of solutions from daily life are given." L.O. 10.2.1.1.b

"Heterogeneous mixtures are classified according to the physical state of the dispersing substance and the dispersing medium." L.O. 10.2.1.1.c

In addition, the unit also includes learning outcomes on the separation and purification techniques of mixtures. There is also an outcome of conducting experiments to separate mixtures, but it is not emphasized which mixtures are meant here. Finally, there were no learning outcomes including the term, hydrophobic in the chemistry curriculum.

Discussion and Conclusion

The aim of this study is to determine freshmen pre-service science teachers' levels of chemical explanations of various daily life phenomena. Also, it is aimed to investigate whether these daily life examples are in accordance with the high school chemistry curriculum in Turkey. The findings of the study are presented under 7 headings regarding the daily life examples included in the questionnaire. After presenting the students' chemical understanding of each daily life phenomenon, how the daily life phenomena and theoretical explanations are covered in the high school chemistry curriculum is analyzed.

The findings showed that the majority of pre-service teachers have a generally correct understanding of diffusion and could partially relate their chemical understanding of diffusion to daily life. However, many of them answered incorrectly or could not answer the statement "*Transition to the gaseous state will take place only if the boiling point of the perfume is lower than the temperature of the room*". Similarly, most of the students who participated in Celik's (2014) study incorrectly thought that the changing state of the perfume could only take place if the boiling point of the perfume is lower than the temperature of the environment. Also, most of the pre-service teachers could not give a correct answer about the chemical process of smell ("*The connection between the perfume molecules and the smell sensors in the nose is not a chemical connection but rather a biological connection*"). This finding regarding smell might be related to the learning outcomes in the curriculum. As a matter of fact, there is no learning outcome that will enable participants to interpret whether the smelling process is chemical or biological. When the learning outcomes related to diffusion are examined holistically, it is seen that there are no learning outcomes that emphasize the relationship between diffusion and daily life. It was determined that there are different misconceptions about the diffusion of gases in the literature. Among these misconceptions are "*The diffusion rate of gases increases as their molecular weight increases", "The diffusion rate of a gas is directly proportional to its molecular weight" and "The molar mass is directly proportional to the diffusion rate of gases*" (Meşin et al., 2019). In addition to these misconceptions, the findings of this study revealed that students had the misconception "*Transition to the gaseous state will take place only if the boiling point of the perfume is lower than the temperature of the room*". This misconception also shows that students cannot relate chemistry knowledge to their daily experiences (for example, feeling the smell of perfume sprayed from a distance even in cold weather).

The findings related to the temperature showed that most of the pre-service teachers had incorrect answers or could not give any answer to most of the statements. Most of them gave incorrect answers, especially to the statement; *"There will be a difference in temperatures of the two chairs. The metal one will heat up more if the room is hot and will cool off more if the room is cold*". Previous literature studies on thermal energy and related concepts in everyday contexts (e.g. Chu et al., 2012; Harrison et al., 1999) showed that students had alternative conceptions about thermal equilibrium (*"The temperature of different objects is different even though they have been placed in the same environment over an extended period of time"*). Also, the temperature in the context of heat transfer and specific heat capacity is not covered in the high school chemistry curriculum. This might also explain their low levels of understanding.

The findings related to the burning of a candle showed that most of the participants had a correct understanding of the reaction between the wax and oxygen. The findings also revealed their understanding of combustion reactions and the law of conservation of mass. However, they had incorrect answers, especially about the law of conservation of mass and combustion reactions in open and closed systems. Although the relationship between the burning of wax and combustion reactions is not included in the chemistry curriculum, scientific explanations (definitions) of combustion reactions and the law of conservation of matter are among the learning outcomes. Similar misconceptions regarding the conservation of mass during combustion reactions are also found in the literature. Boujaoude's (1991) study at the middle school level showed that most of the students thought there would be no change when a candle burned in a closed vessel. Also, Haidar (1997) found that pre-service chemistry teachers did not develop an appropriate conceptual understanding of the conservation of matter and related concepts.

Students' conceptual understanding of heavy water and isotopes showed that they had a very limited understanding in general. Many of the participants thought that heavy water is distilled water, or they could not answer the question. Heavy water is a form of water that contains only deuterium rather than the common hydrogen-1 isotope (Britannica the Editors of Encyclopedia, 2022) whereas distilled water is pure water, produced with the distillation of plain water (containing hydrogen-1). Also, nearly half of them thought that *"The difference between a regular hydrogen atom and a deuterium atom is in the number of protons in the nucleus"* which is an incorrect statement. In the study of Molu et al. (2016), 68% of the pre-service teachers were able to explain the concepts of isotope and radioisotope correctly. However, in this study, the percentage of correct answers was found to be 22.53%. In Tsaparlis et al.'s (2013) study with Turkish and Greek participants, an average of 20% of Greek pre-service teachers and 11% of Turkish pre-service teachers gave acceptable or partially acceptable answers, while a large number (on average about 50% of Greek students and 27% of Turkish students) avoided answering the questions. Similar to the finding of this study, Tsaparlis et al. (2013) found that the most common misconception was the confusion of "mass number" with "atomic number". The current chemistry curriculum does not include any learning outcomes related to heavy water and deuterium, but only one learning outcome that includes the definition of the concept of the isotope. This may be one of the reasons why the participants gave incorrect answers or did not give answers to the questions on isotopes and heavy water.

Participants' responses about "limestone reacting with acid" showed that this phenomenon is one of the daily life phenomena with the highest number of correct answers. One of the reasons for this may be that the learning outcomes in the curriculum directly include the effects of acid rain on nature and historical structures. The findings showed that the lowest percentage of the correct responses was on the aggregation state of limestone *"The solid limestone changed aggregation state; in the course of the reaction it turned into liquid and after to gas".* A similar finding regarding the statement was obtained from Celik's (2014) study, as well. This may indicate that the participants only interpreted the reaction as far as they could observe it (at a macroscopic level), as they were informed in the questionnaire that the limestone rock or dust completely disappeared when the reaction was completed. Therefore, it can be interpreted that they lacked the ability to think about the reaction at the sub-molecular level. The pre-service teacher in this study had adequate understanding related to reaction rate, acid-base reactions, and the related daily life phenomena; acid rain. However, there are various studies that reveal that students have misconceptions about these concepts (Cakmakci et al., 2005; Pabuçcu, 2016; Karslı & Ayas, 2014; Kolomuç & Tekin, 2011). For example, Pabuçcu's (2016) study showed that first-year pre-service teachers did not have sufficient knowledge about how acid rain occurred and its effects on the environment. Cakmakci et al. (2005) found that even after instruction, many students use conceptions that are not consistent with a scientific perspective, and have difficulties in understanding the relationships between concentration and reaction rate. However, the findings of the current study demonstrate that most of the participants had a correct understanding of the factors influencing reaction rate (particle size, temperature, concentration).

Pre-service science teachers' understanding of redox reactions (rusty nail example) showed that this phenomenon is also one of the daily life phenomena with a higher number of correct answers. One of the reasons for this might be the inclusion of topics such as redox reactions and corrosion in the chemistry curriculum. However, this daily life example in the questionnaire shows that pre-service teachers (40.85%) have some misconceptions about the type of chemical bond formed (ionic bond) during redox reactions. (*"During a reaction between metal and oxygen a covalent bond forms between the metal atoms and the oxygen atoms"*). Treagust et al. (2014) state that redox reactions, in particular, are regarded by students as one of the most difficult topics as they involve multiple levels of chemical representation (e.g. macroscopic, sub-microscopic, symbolic) and there are four models, named the oxygen model, the hydrogen model, the electron model, and the oxidation numbers model, that can explain the complex nature of redox reactions. For this reason, in a question/topic related to redox reactions, students may focus only on reduction and oxidation and may not think in detail about the type of bond formed. Nakhleh (1992) asked students' views on what happens when iron rusts and found that they had some misconceptions such as *"Displacement hm one physical location to another occurs", "The material is modified (another form of the original material)", 'Transmutation occurs"*. Even if it is not the case in this present study, pre-service teachers could not make the connection between electron exchange and ionic bonding.

Most of the pre-service teachers possessed an adequate understanding of water and oil mixtures. The percentages of correct answers were more than fifty percent for each statement. One of the interesting findings of the study is that the students answered the questions correctly, especially the questions involving the concept of hydrophobic particles (parts), which is not included in the high school curriculum. The reason for this may be that they have heard this term in daily life or in different courses, although it is not included in the curriculum.

In this study, the "Chemical Explanations of Daily Phenomena" Questionnaire developed by Shwartz et al. (2006) was used. Shwartz et al. (2006) also developed and used different questionnaires to determine the various levels of chemical literacy. One of the limitations of the present study is that only the students' ability to relate chemistry to daily life was examined and aspects such as the multi-dimensional level were not identified. The multi-dimensional level focuses on students' ability to understand a chemistry-related text or to recognize chemistry-related aspects in content such as a newspaper article. Therefore, through different texts and current global and local events (e.g. vaccines, nanotechnology, alternative energy resources, sustainability, carbon footprint, global environmental problems, etc.), students' multi-dimensional chemical literacy level can be identified and their awareness of socioscientific issues can be enhanced.

The findings also showed that students' answers regarding the topics that were not sufficiently covered in the high school curriculum were generally incorrect. The 2018 chemistry curriculum was simplified compared to the previous curriculum, but concepts such as radioactivity, heat transfer, and specific heat capacity were not included. Although some of these concepts are included in the curricula of other disciplines such as physics, they are considered to be important topics for high school chemistry. It is suggested that these topics should be integrated into the curriculum in future revision.

Some limitations of the study should be mentioned. The study was conducted with pre-service science teachers who were first-year students and new entrants to the university. Examining only the chemical literacy levels of pre-service teachers may be partially insufficient in interpreting the findings. In addition, the number of pre-service teachers participating in the study was 71. It would be more appropriate to interpret chemical literacy levels with a larger group of participants. Due to these limitations, some suggestions can be made for future research. It is recommended to examine the views of high school students as well as pre-service teachers and thus increase the sample size. Also, conducting longitudinal studies involving different grade levels are recommended for future researchers. In addition, open-ended questions and interviews can further explore participants' chemical understandings and explanations of daily life phenomena. Therefore, future studies could focus on developing open-ended questionnaires about chemistry-related topics in daily life.

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ORIGINAL ARTICLE

Evaluation of Science Teachers' Exam and High School Entrance Exam Science Questions Based on the Revised Bloom Taxonomy¶

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***Abstract**: This study aims to evaluate exam questions set by science teachers for eighth grade students and science questions from a central high school entrance exam (HSEE) according to the Revised Bloom's Taxonomy (RBT). In this study, document analysis technique was employed, as one of the recognized methods of qualitative research. The HSEE science questions and the teacher-prepared exam questions were evaluated separately in the dimensions of knowledge and cognitive process, and the frequency and percentage distribution of the questions were examined according to the RBT. The science teachers' exam questions were found to be the most suitable for factual knowledge in the RBT knowledge dimension, and the most appropriate for the remembering and understanding levels of the cognitive process dimension. It was determined that the HSEE science questions were the most suitable for conceptual and procedural types of knowledge in the RBT knowledge dimension, and for the understanding and analyzing levels in the cognitive process dimension. Both the questions prepared by teachers and the HSEE science questions were not homogeneously distributed in terms of the RBT. It was determined that while the science teachers' exam questions were at the lower level of the cognitive process, the HSEE science questions were at a level higher than those prepared by the teachers.*

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Introduction

EDUCATION has become the most important element of human development by transferring social values to new generations, and is a branch of science that enables the development of societies both past and present. In order to achieve prosperity and peace, societies have afforded significant importance to education and learning at any age, and through this have achieved societal development. Especially over the past century, countries that have invested heavily in education in order to raise citizens who are equipped with the needs of the age have reaped the benefits in a comparatively shorter time to become leaders in every field (Çalık & Çınar 2009; Sahnoun & Abdennadher 2021).

In today's education system, it is important to train students to be successful in both their exams and to possess certain high-level skills. In this context, teachers need to employ exam questions that measure high-level cognitive thinking, and that take the cognitive differences of students into account (Çakıcı & Girgin 2012). The type and level of questions used are considered an important factor in developing higher levels of cognitive thinking skills in students (Kaya & Ahi 2022; Nakiboğlu & Yıldırır 2011). However, studies have shown that exam questions generated by teachers do not generally consider students' cognitive thinking skills (Özmen & Karamustafaoğlu 2006; Salmon & Barrera 2021).

The task of monitoring the behaviors that are desired to be gained through education is the responsibility of teachers (Özkan & Arslantaş 2013). While teachers aim to elicit the desired behaviors in individual students, the purpose of a teacher's evaluation is to determine the extent to which this behavior occurs (Baniasadi et al. 2022; Küçükahmet 2002). Teachers undertake such evaluations at every stage of the teaching process. For this reason, they have a key decision-making position in situations that can determine students' futures. Data obtained from these evaluations have revealed objective results for both the teachers' methods and their students' success. Based on these assessments and evaluation, the success-failure status of students is revealed, together with their level of success or the reasons for failure are known, as well as which students are able to move on to the next level and which students are required to repeat the program (Turgut & Baykul 2014; Yan et al. 2021).

In Turkey, not all students can attend a high school of their choosing. As the number of students who take the necessary entrance exam increases every year, the number of qualified schools remains relatively small. In this context, only students' characteristics can be measured realistically, and their success rankings determined through appropriate assessment and evaluation (Şad & Şahiner 2016). For this reason, students in Turkey are placed in schools according to a centralized exam. Since 1999, eighth-grade students (in their final year of middle school) achieve transfer to high schools via a centralized exam system, and these exams ensure that 10% of students are placed in qualified schools.

The name for this exam has changed over time, having been known as the High School Entrance Exam (HSEE) between 1999 and 2004, the Secondary Education Institutions Exam (SEIE) between 2004 and 2008, the Placement Exam (PE) between 2009 and 2013, the Transition Exam from Basic Education to Secondary Education (TFBSE) between 2013 and 2018, and then back to the High School Entrance Examination (HSEE) since 2018 (Milli Eğitim Bakanlığı [Turkish Ministry of National Education] 2018). In total, there are 1,856 "qualified high schools" throughout Turkey, with 33% as Vocational and Technical Anatolian High Schools, 23% as Science High Schools, 22% as Anatolian Imam Hatip High Schools, 16% as Anatolian High Schools, and 6% as Social Sciences High Schools (Milli Eğitim Bakanlığı [Turkish Ministry of National Education] 2020).

Purpose of the Study

The current study aims to compare the distribution of High School Entrance Examination (HSEE) science questions and questions prepared and used by science teachers in school-based exams in terms of the knowledge and cognitive process dimensions of the Revised Bloom Taxonomy (RBT). In this context, HSEE science questions between 2018 and 2021 and exam questions used by science teachers working in a province of Turkey for eighth-grade students were examined in order to determine the degree to which the science teachers' exam questions were compatible with the HSEE science questions. Answers to the following questions were sought in the study:

- How are the exam questions prepared by science teachers distributed according to the RBT knowledge dimension?
- How are the exam questions prepared by science teachers distributed according to the RBT cognitive process dimension?
- How are the HSEE science questions distributed according to the RBT knowledge dimension?
- How are the HSEE science questions distributed according to the RBT cognitive process dimension?
- To what extent are the science teachers' exam questions and the HSEE science questions compatible according to the RBT?

Importance and Rationale of the Research

Since decisions regarding education are taken in accordance with the results of measurement and evaluation systems, they are of significant importance to any education system (Alt & Raichel 2022; Anderson 2005; Korkmaz

2004). As such, parallelism is required between curricula and measurement tools used to assess student achievement levels. Exam questions asked in the HSEE have the power to affect questions asked in schools' written exams, questions included in textbooks, and those asked to students as part of their courses. For this reason, it is important that qualifying questions are asked in order to appropriately determine students' levels for entrance to qualified schools (Ardahanlı 2018).

In addition to evaluating educational programs through measurement and evaluation, student achievements can be classified by monitoring their development status (Korkmaz 2004). Classification systems are of significant importance in determining both curriculum achievement and the functionality of the teaching process. The taxonomy classification system created by Bloom et al. (1979) aimed to make the complex processes occurring in the minds of individuals as they learned more easily understood. In this context, taxonomies guide evaluation experts, educators, and students alike (Author(s) 2021; Demirel 2007). Taxonomies facilitate communication between individuals in terms of learning objectives by forming a common language, ensuring that curriculum objectives are understood by everyone in the same way, increasing the coherence of activities or evaluations performed, and providing a broad perspective on the positive and negative aspects of curricula (Krathwohl 2002; Panthalookaran 2022).

One of the most important goals of science education is to provide students with high-level thinking skills. However, these skills can only be validated through the measurement of high-level thinking characteristics in exams. Students mostly organize their studying in accordance with the exams that they will sit. Therefore, if the exam questions asked are of the kind that measures superficial knowledge, students are likely to choose a superficial learning process path. It is a common occurrence that many students who finish their high school education cannot readily solve HSEE questions since they encountered mostly low-level questions in their school exams, and are therefore surprised when they encounter higher-level questions in the HSEE since they lack the experience in solving these types of questions. The levels of questions prepared by teachers are therefore of significant importance in terms of the quality of science teaching received by students. It is thought that determining the levels of questions prepared by science teachers and then comparing them with the levels of questions in the HSEE will prove useful for education administrators, textbook developers, educational measurement and evaluation specialists, and also school teachers.

The current research is also considered important in terms of providing the opportunity to evaluate exam questions prepared by science teachers and the HSEE science questions together, and thus allowing for a general evaluation of the questions being asked to students. In most studies conducted in Turkey in this field, it has been determined that the questions only

Table 1. Original Bloom Taxonomy (Krathwohl 2002, p213).
1.0 Knowledge: Students only remember and repeat knowledge of 1.10 Specifics 1.11 Terminology 1.12 Specific facts 1.20 Ways and means of dealing with specifics 1.21 Conventions 1.22 Trends and sequences 1.23 Classifications and categories 1.24 Criteria 1.25 Methodology 1.30 Universals and abstractions in a field 1.31 Principles and generalizations 1.32 Theories and structures
2.0 Comprehension: Students' abilities to integrate behaviors gained in previous levels 2.1 Translation 2.2 Interpretation 2.3 Extrapolation
3.0 Application: Students' application of acquired knowledge and skills to new situations encountered
4.0 Analysis: Making connections between knowledge by thinking critically Analysis of …. 4.1 Elements 4.2 Relationships 4.3 Organizational principles
5.0 Synthesis: Students combine the pieces to create a new product by considering the harmony between pieces Production of …. 5.1 Unique communication 5.2 Plan, or proposed set of operations Derivation of …. 5.3 Set of abstract relations
6.0 Evaluation: Making decisions based on students' prior knowledge Evaluation in terms of …. 6.1 Internal evidence *Judgements in terms of ….* 6.2 External criteria

consider the cognitive process dimension of the RBT. In the current study, analyses were performed to take into account both the knowledge and cognitive process dimensions of the RBT.

The Original Bloom Taxonomy

Bloom's Taxonomy is a progressive one-dimensional classification of learning in the cognitive, affective, and psychomotor fields (Krathwohl 2002). The work entitled "Taxonomy of Educational Objectives the Classification of Educational Goals Handbook 1 Cognitive Domain" by Bloom et al. (1956) was the first in its field, and was aimed at helping the developers of evaluation programs and in the classification of educational goals (Bloom et al. 1979).

In Bloom's Taxonomy, the cognitive field consists of six hierarchical levels (Krathwohl 2002), which are detailed together with their subcategories in **Table 1**.

Measurement experts have used Bloom's Taxonomy as a guide to developing test situations, by those developing educational programs, and by teachers in organizing classroom-based education (Anderson 1999; Krathwohl 2002; Rayahu 2018; Urinbayeva 2022).

Although many alternatives were presented up until the revision of Bloom's Taxonomy, it managed to stay ahead of time by keeping up to date (Anderson 2005). Anderson and Krathwohl (Revised Bloom Taxonomy), Marzano and Kendall (New Taxonomy of Educational Goals), and Taba's Taxonomies, Classifications of Tuckman, Haladyna, Williams, Hannah, and Michaelis, De Block, Hauenstein, Reigeluth and Moore, Gerlach and Sullivan, Romizowski, Quellmalz, Gagne-Merrill, Stahl and Murphy, Guilford's Intelligence Model, Gardner's Multiple Intelligence Model, De Corte Model can be given as examples of taxonomies developed in the cognitive field. However, these alternative classifications did not change that much from the main view and thought presented in Bloom's original classification; mostly just changing the order and name of some levels.

The reasons for revising the original Bloom's Taxonomy were as follows:

- To accommodate changes in educational systems due to technological developments;
- With the emergence of constructivist learning theory, it was thought that the original taxonomy was insufficient to measure high-level skills;
- The incompatibility of the original taxonomy with real-world problems;
- Evaluation and analysis levels did not always present a clear answer;
- The original taxonomy was claimed to have been prepared based on higher education and failed to include examples related to primary or secondary or education;
- Deficiencies in explaining dynamism and individuality in learning;
- Knowledge levels were presented in noun and verb forms;
- The sequencing of levels was a prerequisite; and,
- The synthesis level also included the evaluation level (Arı 2011; Ayvacı & Türkdoğan 2010; Günaydın 2018; Krathwohl & Anderson 2010; Tutkun & Seçil 2012).

The Revised Bloom Taxonomy

The most important difference that distinguishes the RBT from its original is that the cognitive field was made two-dimensional (Krathwohl 2002). With RBT, noun and verb cases are separated from each other and are therefore easier to understand. In the knowledge dimension, noun cases consist of four

Table 2. RBT Knowledge Dimensions and Subcategories (Krathwohl 2002, p214).

A.	Factual knowledge: Elements necessary for students to solve problems through detailed subject knowledge. Knowledge of …. A1. Terminology (e.g., the alphabet) A2. Specific details and elements (e.g., a country's production and exports)
B.	Conceptual knowledge: Factors that ensure harmony between the basic elements of a complex structure. Knowledge of …. B1. Classifications and categories (e.g., different geological times) B2. Principles and generalization (e.g., the basic laws of physics) B3. Theories, models, and structures (e.g., genetic models in biology)
C.	Procedural knowledge: Criterion of how to apply methods, techniques, and skills to do something. Knowledge of …. C1. Subject-specific skills and algorithms (e.g., skills necessary for high jumping in athletics) C2. Subject-specific techniques and methods (e.g., techniques used by scientists to solve problems) C3. Criteria for determining when to use appropriate procedures: (e.g., which method to use to solve mathematics equations)
D.	Metacognitive knowledge: Awareness that students' possess cognitive knowledge. D1. Strategic knowledge: (e.g., auxiliary strategies to increase persistence in memory, coding, abbreviation) D2. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge (e.g., determining students' strengths and weaknesses, preparing a project according to their level) D3. Self-knowledge (e.g., students who know their weaknesses employing different strategies to achieve exam success)

categories (see **Table 2**), whilst in the cognitive process dimension, verb cases consist of six levels (see **Table 3**) in the RBT (Arı 2011).

The updated taxonomy focuses in detail on the "Comprehension, Application, Analysis, Evaluation and Creation" levels, which enable the transfer of what has been learned, rather than the "Remembering" level, so as to ensure the permanence of cognitive processes (Anderson & Krathwohl 2014). The cognitive process dimension subcategories are presented as shown in **Table 3**.

The current state of the revised taxonomy, consisting of two dimensions such as knowledge and cognitive process, is summarized in **Table 4**.

Some Related Studies in Science Education

In their study, Tanık and Saraçoğlu (2011) analyzed written exam questions prepared by science and technology teachers according to the cognitive process dimension of RBT. A total of 1,061 questions were analyzed, and it was determined that 51.6% of the exam questions were at the remembering level, 33.1% at the understanding level, 6.2% at the applying level, and 9.1% at the analyzing level. No questions were found at the levels of evaluating or

Table 3. RBT Cognitive Process Dimensions and Subcategories (Krathwohl 2002, p215).

1. REMEMBERING	Restoring knowledge from memory.
1.1 Recognizing	Comparing knowledge presented with knowledge in long-term memory.
1.2 Recalling	Accessing knowledge.
2. UNDERSTANDING	Making sense of what they previously learned in writing, verbally, and with figures.
2.1 Interpreting	Converting knowledge from one form of expression to another form of expression and representation.
2.2 Exemplifying	Students find a special example or analogy to the concepts or principles they are given.
2.3 Classifying	Student place an example or situation in a certain category of principles or concepts.
2.4 Summarizing	Students can present knowledge by extracting short summaries from a topic, theme, or video they are given.
2.5 Inferring	Students attempt to reveal the meaningful essence hidden in the body of knowledge.
2.6 Comparing	Revealing similar and different aspects between more than one event, problem, thought, situation or object.
2.7 Explaining	Expressing whole knowledge more clearly to students.
3. APPLYING	Using the transaction path in the event they encounter.
3.1 Executing	Using the link provided when solving questions.
3.2 Implementing	When facing unfamiliar tasks, students select and use actions to perform the task.
4. ANALYZING	Breaking down material into parts, and determining how parts relate to the whole and to each other.
4.1 Differentiating	How to distinguish parts in a knowledge community.
4.2 Organizing	Identifying the important and appropriate elements in the whole and organizing them coherently.
4.3 Attributing	Trying to reveal an author's point of view and the background of an article by analyzing a given text.
5. EVALUATING	Judging based on standards and measurements.
5.1 Checking	Students searching for and examination of inconsistencies in given knowledge.
5.2 Critiquing	Students make criticism according to hypotheses they create or from others to achieve the required results.
6. CREATING	Creating a unique new product by combining data.
6.1 Generating	Creating alternative solutions within certain criteria in the face of the problems faced by students.
6.2 Planning	Making arrangements to solve problems faced by students, to develop a plan.
6.3 Producing	Realizing a plan to solve a problem.

Table 4. RBT Classification Table (Krathwohl 2002, p216).

KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	1. Remembering	2. Understanding	3. Applying	4. Analyzing	5. Evaluating	6. Creating
A. Factual knowledge						
B. Conceptual knowledge						
C. Procedural knowledge						
D. Metacognitive knowledge						

creating. Ayvacı and Türkdoğan (2010) discussed the role of Bloom's Taxonomy in eliminating the gap in measurement and evaluation tools by analyzing the exam questions prepared by science teachers in the cognitive process dimension of RBT. As a result, it was found that most of the questions were at the level of remembering (55%).

Demir (2011) conducted a study to see if any significant difference existed between the written exam questions prepared by primary school fifth-grade teachers and sixth-grade science and technology teachers during the 2007-2008 academic year. Through document analysis, the questions were classified according to Bloom's Taxonomy, and it was seen that a significant difference existed between the levels of the exam questions. In a study by Yolcu (2019), third- and fourth-grade student achievement levels were analyzed based on the 2017 science curriculum in accordance with the RBT. Gains were noted for the conceptual level (72%) of the knowledge dimension and also for the understanding level (43%) of the cognitive process dimension. In a study by Ataş and Güneş (2020), sixth-grade written science course exam questions were evaluated based on the RBT. From the 543 exam questions examined though document analysis, it was determined that the questions were collected in the remembering and understanding levels of the cognitive process dimension and the factual knowledge type of the knowledge dimension.

In research by Sezer (2018), exam questions prepared by science teachers were analyzed through document analysis and compared to science questions asked in the TFBSE centralized exams and the international PISA and TIMSS exams according to Bloom's Taxonomy, with the aim to determine whether or not consistency existed between the teachers' exam questions and their understanding of teaching and learning. The eighth-grade science exam questions were investigated according to the cognitive knowledge levels of the RBT, TIMSS (2015), and PISA (2015). In addition, the extent to which both international exams covered the students' achievements based on the curriculum was examined. The analysis results emphasized that the TFBSE exams remained at a lower level than either the PISA or TIMSS exams, and that the exam questions prepared by the science teachers and the TFBSE exam questions did not fully address the required scientific achievements.

In her study, Akyürek (2019) analyzed HSEE science questions implemented for the first time in 2018 with those of the TFBSE exams held in 2016 and 2017, together with the achievements specified in the curriculum. Through document analysis, 60 science questions and 78 outcomes were leveled according to the two dimensions of the RBT. It was determined that the TFBSE and HSEE exam questions were stacked in the procedural knowledge level of the knowledge dimension and in the understanding level of the cognitive process dimension. However, it was noted that no questions were asked from certain cognitive levels in either exam. In addition, it was stated that although there was a consistency identified between the achievements and the exam questions, it was not possible to determine the high-level thinking skills of the students in this way.

In a research study by Cangüven (2019), the achievements identified in the science curriculum developed and implemented by the Turkish Ministry of National Education in 2013 and 2018 were analyzed and compared according to the cognitive process dimension of RBT. While a decrease was seen in the levels of remembering, applying, analyzing, and evaluating in the 2018 program compared to 2013, there was an increase noted in the levels of understanding and creating. Güven (2014) examined the questions set in the secondary school sixth-, seventh-, and eighth-grade science and technology curricula according to the cognitive process dimension of the RBT. From a total of 516 questions analyzed, it was reported that most of the questions were classified as being of low-level thinking. Through document analysis, Toksoy (2018) examined ninth-, 10th-, and 11th-grade chemistry questions in accordance to Bloom's cognitive process dimension. It was determined that the written exam questions prepared by chemistry teachers concentrated on the first three levels of the taxonomy, with very few questions having been asked from the higher cognitive levels.

In their study, Zorluoğlu et al. (2016) analyzed and evaluated secondary school chemistry course curriculum achievements in accordance to the two dimensions of the RBT. Through document review technique they examined 154 achievements published in 2013. When analyzed in terms of the knowledge dimension of the RBT, 25% was attributed to factual knowledge, conceptual knowledge was 59%, procedural knowledge was 11%, and metacognitive knowledge was 5%. When analyzed in terms of the cognitive process dimension of the RBT, they found that 7% corresponded to the remembering level, 67% to understanding, 5% to applying, 20% to analyzing, and 1% to the evaluating level. However, no objective belonging to the creating level was determined.

In a study by Gökulu (2015), science and technology questions from the TFBSE exams held in 2013-2014 were evaluated according to the RBT together with exam questions created by eighth-grade science and technology teachers working in Çanakkale for the same year. The analysis showed that 71% of the teachers' written exam questions were at the remembering level, while questions from the TFBSE exams showed 50% to be low cognitive level and 30% at high cognitive level. Eş (2005) evaluated the HSEE science questions and science course exam questions according to Bloom's Taxonomy, and stated that the teachers' exam questions accumulated in the low-level while the HSEE questions concentrated in the analysis, synthesis, and evaluation levels, which are each higher cognitive levels.

In research published by Salvato (2011), the thinking levels of 2,718 questions from four general chemistry books widely used in Texan universities were analyzed according to Bloom's Taxonomy along with 2,591 questions from a non-traditional university chemistry textbook. The analysis results revealed that 14% of the general chemistry textbook questions were identified as being in the knowledge level, plus 20.5% for comprehension, 55.2% for application, 9.8% for analysis, 0.1% for synthesis, and 0.4% in the evaluation level. The questions in the non-traditional chemistry textbook were shown to be 10.7% in the knowledge level, 49% for comprehension, 21.5% for application, 17.9% for analysis, 0.7% for synthesis, and 0.2% in the evaluation level. It was concluded that the general chemistry textbooks' questions were mostly high-level, while the non-traditional chemistry textbook questions were mostly low-level.

Lee et al. (2015) compared achievements set out in the primary school science curricula of Singapore and South Korea for the third to sixth grade, and then analyzed them according to the RBT. When Singapore's curriculum was examined, it was determined that 86.7% of the achievements in the cognitive process dimension were in the understanding and applying levels, and 13.3% were in the remembering level. No objectives were identified in the analyzing, evaluating, or creating levels. When analyzed according to the knowledge dimension of the RBT, it was seen that 59% of the objectives were accumulated at the conceptual knowledge level. When the South Korean curriculum was examined, it was determined that 87.7% of the objectives were accumulated at the cognitive process dimension, in the remembering and understanding levels, whilst 2.7% were in the creating and knowledge level, and 73.2% in the conceptual knowledge level. Amer (2006) examined the relationship between the RBT and the original taxonomy from a critical perspective. In the study, Amer criticized the original taxonomy by stating its deficiencies and explaining the reasons for its renewal. As a result, he stated that thanks to the RBT, teachers can more easily organize teaching activities, understand the relationship between learning and evaluation processes, and more readily analyze educational goals.

In summary, in the Turkish literature, attempts have been made to evaluate HSEE exam questions according to the RBT, compare the achievements set out in curricula with the HSEE exam questions, the placement of questions in textbooks according to the taxonomy, and the level of written exams in terms of the RBT. The applicability and description of the RBT and the convenience afforded to the measurement/evaluation and learning processes have been emphasized in studies conducted in other countries. Most research were conducted by examining the single dimension of the RBT. As can be understood from the literature analysis presented here, no studies were found in which the questions used by eighth-grade science teachers in their course exams and science questions from the HSEE that addressed both dimensions of the RBT, which is considered to be an important gap in the relevant literature that the current study aims to fill.

Materials and Methods

The qualitative research approach was employed in this study, incorporating data collection methods such as interviews, document analysis, and observation (Yıldırım & Şimşek 2011). The document analysis method, which is one of the recognized qualitative research approaches, was selected since the method examines materials and documents etc., and has been frequently used in educational research to examine curricula, textbooks, assignments, and written exam questions (Bowen 2009). One of the main strengths of document analysis is said to be its reliability and economical application. It is deemed reliable since the content of the documents under examination does not change, and it is seen as economical in this respect since the documents are examined and revealed by the most people (Karasar 2016).

Sampling

The sample of this study consisted of 1,100 questions applied by 35 science teachers in eighth-grade classes of schools affiliated to the Turkish Ministry of National Education in one province of Turkey, plus 80 science questions that had been asked in the HSEE during the 4 years from 2018 to 2021.

Data Collection Tools

The data were collected using the document analysis method, which is a recognized method of collecting qualitative research data through the examination of existing documents and records. According to Karasar (2016), document analysis involves finding and reading sources for a specific purpose, and then evaluating them based on the study's design. The exam questions examined in the current research were collected from teachers by visiting schools in person, whilst the HSEE science questions were extracted from the official website of the Turkish Ministry of National Education (http://meb.gov.tr/).

Process of Data Collection, Analysis, Validity, and Reliability

The science teachers were initially contacted and informed about the purpose of the study. The place and importance of Bloom's Taxonomy in education were shared with the teachers, and their contribution to the research was then requested. The exam questions prepared by science teachers were included in the research where they were provided voluntarily.

The study determined the knowledge type and cognitive process level of each question examined. It was determined which questions corresponded to which knowledge type (i.e., factual, conceptual, procedural, or metacognitive). For the cognitive process dimension, it was determined which levels (i.e., remembering, understanding, applying, analyzing, evaluating, or creating) were deemed appropriate for each question. Frequency and percentage distributions of the exam questions prepared by the science teachers in both the knowledge and the cognitive process dimensions of the HSEE were tabulated.

A random selection of 40 teacher-devised questions and 10 HSEE science questions were analyzed by three different researchers in order to determine the reliability of the analysis of exam questions prepared by science teachers and HSEE science questions. Considering the analyses, the level of agreement between the researchers' results was calculated as a percentage, with the consistency between the researchers calculated according to Miles and Huberman's (1994) reliability coefficient formula.

$$\text{Reliability} = \text{Consensus}/\frac{Consensus}{Consensus+Disagreement}$$

According to Yıldırım and Şimşek (2011), when a value of 0.70 or above is obtained using this formula, the studies are considered to be reliable. In the exam questions prepared by the science teachers, the percentage of agreement between the researchers was calculated as being 0.80 for the knowledge dimension and 0.82 for the cognitive process dimension. For the HSEE science questions, the reliability was established as being 0.87 for the knowledge dimension and 0.80 for the cognitive process dimension.

A suitable sample was selected in order to increase the external validity of the study. By providing detailed information about all stages of the study, it was ensured that the results of the research could be generalized to similar situations in the future. One of the methods applied to increase reliability in qualitative research is to compare the results obtained with those of researchers who conducted similar studies (Yıldırım and Şimşek 2011). In order to increase the reliability of the study conducted in this context, the previous studies conducted based on the RBT were also examined.

Results

"*How are the exam questions prepared by science teachers distributed according to the RBT knowledge dimension?*"

Table 5. Individual Analysis of RBT Knowledge Dimension Exam Questions.

	Factual Knowledge	Conceptual Knowledge	Procedural Knowledge	Metacognitive Knowledge
Teacher	%	%	%	%
T1	74	6	20	-
T2	36	50	14	-
T3	28	44	28	-
T4	40	41	17	2
T5	30	43	27	-
T6	21	57	22	-
T7	60	20	20	-
T8	56	36	8	-
T9	25	30	35	10
T10	72	4	24	-
T11	61	27	12	-
T12	72	14	14	-
T13	55	39	6	-
T14	50	50	-	-
T15	56	12	-	4
T16	55	10	25	8
T17	52	24	20	4
T18	50	43	7	-
T19	82	12	6	-
T20	90	3	7	-
T21	71	24	5	-
T22	68	29	-	4
T23	56	32	12	-
T24	54	41	5	-
T25	72	20	8	-
T26	82	15	3	-
T27	70	26	2	2
T28	60	33	4	3
T29	55	10	35	-
T30	51	39	8	2
T31	75	20	5	-
T32	35	50	10	5
T33	44	40	16	-
T34	50	15	35	-
T35	60	25	15	-

The findings obtained by analyzing the exam questions prepared by the science teachers in accordance with the RBT's knowledge dimension are presented in **Table 5**.

When **Table 5** is examined, it can be seen that the questions prepared by the science teachers were generally concentrated on the factual, conceptual, and procedural knowledge types. It was determined that the science teachers mostly used questions based on factual knowledge. It can be seen that T20 asked 90% of questions based on factual knowledge, whilst T6 asked conceptual knowledge questions at the rate of 57%. The teachers whose highest numbers of questions were on procedural knowledge were T9, T29, and T34 with 35%. The science teachers were noted to have asked only a limited number of questions of the metacognitive knowledge type, which is the highest type level of the knowledge dimension. These teachers were T4, T9, T15, T16, T17, T22, T27, T28, T30, and T32, with the highest proportion being 10% for T9.

Considering the findings presented in **Table 5**, the distribution of questions employed by the science teachers in the total knowledge dimension were determined and illustrated in **Figure 1**.

According to **Figure 1**, when the exam questions prepared by the science teachers were analyzed according to the RBT's knowledge dimension, it can be seen that 56.2% of the questions were on factual knowledge, 28.1% were on conceptual knowledge, 14.4% were on procedural knowledge, and 1.3% were on metacognitive knowledge.

"*How are the exam questions prepared by science teachers distributed according to the RBT cognitive process dimension?*"

The findings obtained by analyzing the exam questions prepared by the science teachers in accordance with the RBT's cognitive process dimension are presented in **Table 6**.

In **Table 6**, the exam questions prepared by the science teachers were analyzed according to the cognitive process dimension of the RBT. The questions asked by the science teachers generally focused on remembering and understanding. It is notable, however, that there were no questions asked at the creating level. As can be seen, T26 asked 70% of questions at the remembering level, T14 asked 65% of questions at the understanding level, T34 asked 35% of questions at the applying level, T32 asked 55% of questions at the analyzing level, and T16 asked 15% of questions at the evaluating level.

Taking into account the findings in **Table 6**, the distribution of the science teachers' questions according to the RBT's cognitive process dimension are illustrated in **Figure 2**.

According to **Figure 2**, when the exam questions prepared by the science teachers were analyzed based on the cognitive process dimension of the RBT, it can be seen that 37.4% of the questions were at the remembering level, 40.8% were at the understanding level, 10.8% were at the applying

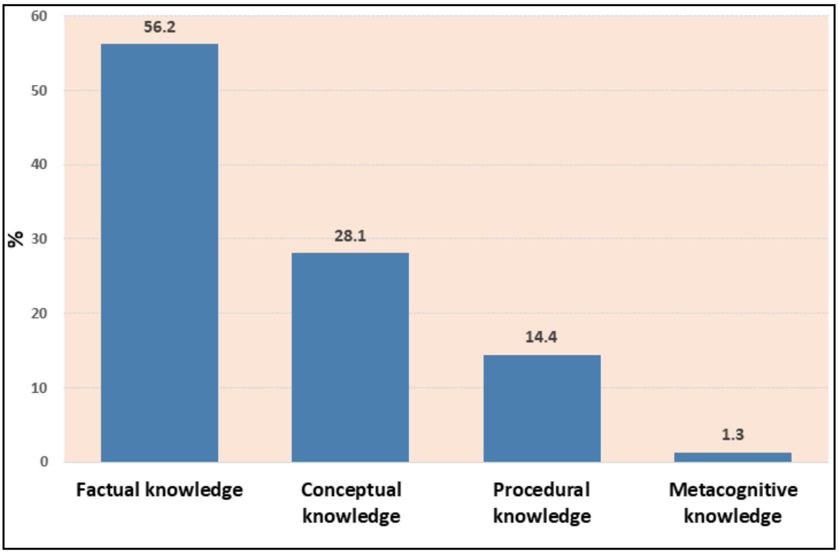

Figure 1. Exam Questions by RBT Knowledge Dimension.

level, 7.3% were at the analyzing level, and 3.7% were at the evaluating level. However, there were no questions asked at the creating level.

The total numbers showing which level the exam questions corresponded to in both the knowledge and cognitive process dimensions of the RBT are shown in **Table 7**.

Distribution of the 1,100 questions prepared by science teachers across both dimensions of the RBT are shown in **Table 7**. Accordingly, it can be seen that questions corresponding to the A1 level (Factual/Remembering) were the most popular with 360 questions, followed by the A2 level (Factual/Understanding) with 260 questions. As seen, the science teachers clearly favored questions at the remembering level under the factual knowledge type, at the understanding level under the conceptual knowledge type, at the applying level under the procedural knowledge type, and questions at the evaluating level under the metacognitive knowledge type.

"How are the HSEE science questions distributed according to the RBT knowledge dimension?"

Findings obtained from analysis of the HSEE science questions are presented in **Table 8** according to the RBT knowledge dimension by exam year.

Table 6. Individual Analysis of RBT Cognitive Process Dimension Exam Questions.

	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating
Teacher	%	%	%	%	%	%
T1	66	14	20	-	-	-
T2	14	58	21	7	-	-
T3	20	36	28	12	4	-
T4	62	14	16	6	2	-
T5	49	36	12	-	3	-
T6	39	46	7	4	4	-
T7	40	40	15	-	5	-
T8	54	38	8	-	-	-
T9	10	60	15	5	10	-
T10	28	52	20	-	-	-
T11	39	46	9	-	6	-
T12	55	31	14	-	-	-
T13	36	61	3	-	-	
T14	20	65	-	5	10	
T15	24	36	20	16	4	
T16	5	40	20	20	15	
T17	32	40	8	8	12	
T18	38	57	5	-	-	
T19	55	39	3	3	-	
T20	55	39	6	-	-	
T21	50	41	2	5	2	
T22	43	50	-	4	3	
T23	50	32	12	6	-	
T24	38	43	3	16	-	
T25	28	56	8	8	-	
T26	70	18	3	3	6	
T27	33	54	-	11	2	
T28	38	47	4	-	11	
T29	30	40	30	-	-	
T30	46	28	3	13	10	
T31	20	55	5	10	10	
T32	15	25	-	55	5	
T33	12	36	8	40	4	
T34	40	25	35	-	-	
T35	55	30	15	-	-	

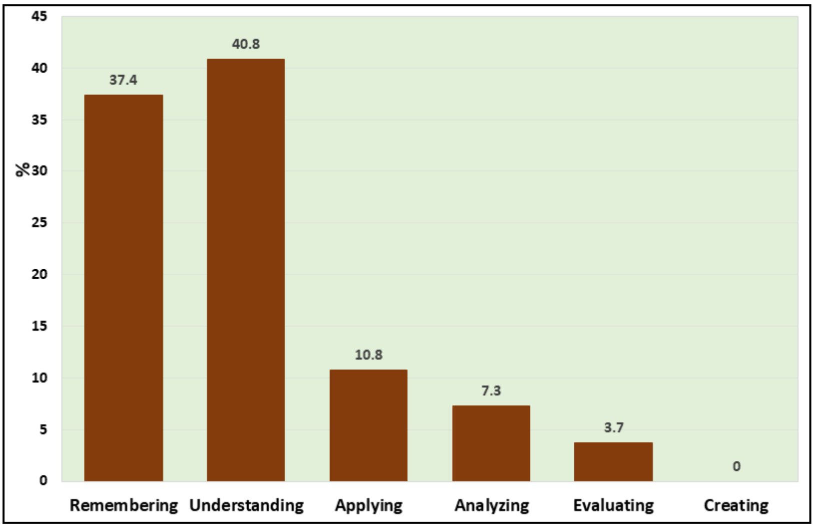

Figure 2. Exam Questions by RBT Cognitive Process Dimension.

Table 7. Numerical Distribution of RBT Exam Questions.

KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	1. Remembering	2. Understanding	3. Applying	4. Analyzing	5. Evaluating	6. Creating
A. Factual knowledge	360	260	0	9	5	0
B. Conceptual knowledge	87	162	0	50	16	0
C. Procedural knowledge	0	17	103	15	4	0
D. Metacognitive knowledge	0	0	0	0	12	0

Table 8. Analysis of HSEE Science Questions for RBT Knowledge Dimension.

	2018	2019	2020	2021
Knowledge dimension	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Factual	1 (5)	0 (0)	2 (10)	2 (20)
Conceptual	11 (55)	7 (35)	9 (45)	10 (50)
Procedural	7 (35)	12 (60)	8 (40)	8 (40)
Metacognitive	1 (5)	1 (5)	1 (5)	0 (0)
Total	20 (100)	20 (100)	20 (100)	20 (100)

According to **Table 8,** it can be seen that most of the HSEE science questions for 2018, 2019, 2020, and 2021 focused on the conceptual and procedural knowledge of the RBT knowledge dimension. For 2018, 5% of the questions were of the factual knowledge type, 55% were of the conceptual knowledge type, 35% were of the procedural knowledge type, and 5% were of the metacognitive knowledge type. For 2019, 35% of the questions were of the conceptual knowledge type, 60% were of the procedural knowledge type, and 5% were of the metacognitive knowledge type. It is notable that no questions were asked of the factual information type in the 2019 HSEE. For 2020, 10% of the questions were of the factual knowledge type, 45% were of the conceptual knowledge type, 40% were of the procedural knowledge type, and 5% were of the metacognitive knowledge type. Finally, for 2021, 20% of the questions were of the factual knowledge type, 50% were of the conceptual knowledge type, and 40% were of the procedural knowledge type. Notably, no questions were asked of the metacognitive knowledge type in the 2021 HSEE.

"How are the HSEE science questions distributed according to the RBT cognitive process dimension?"

Findings obtained from analysis of the HSEE science questions are presented in **Table 9** according to the RBT cognitive process dimension by exam year.

Table 9 shows that the 2018 and 2019 HSEE science questions were mostly found in the cognitive process dimension of the RBT, in the levels of understanding, analyzing, and applying. As can be seen, for 2018 a total of 35% of the questions asked were at the understanding level, 25% were at the applying level, 35% were at the analyzing level, and 5% were at the evaluating level. For 2019, 40% of the questions were at the understanding level, 20% were at the applying level, 30% were at the analyzing level, and 10% were at the evaluating level. Notably, no questions were asked at the remembering or creating levels in any of the four exam years examined. As can be seen, the 2020 and 2021 HSEE science questions were mostly accumulated in the cognitive process dimension of the RBT, in the levels of understanding and analyzing. For 2020, 45% of the questions were at the understanding level, 10% were at the applying level, and 45% were at the analyzing level. Notably, no questions were asked in 2020 on the levels of remembering, evaluating, or creating. For 2021, 35% of the questions were at the understanding level, 15% were at the applying level, 45% were at the analyzing level, and 5% were at the evaluating level. For 2021, no questions were asked at either the remembering or creating levels.

Table 9. Analysis of HSEE Science Questions for RBT Cognitive Process Dimension.

	2018	2019	2020	2021
Cognitive process dimension	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Remembering	0 (0)	0 (0)	0 (0)	0 (0)
Understanding	7 (35)	8 (40)	9 (45)	7 (35)
Applying	5 (25)	4 (20)	2 (10)	3 (15)
Analyzing	7 (35)	6 (30)	9 (45)	9 (45)
Evaluating	1 (5)	2 (10)	0 (0)	1 (5)
Creating	0 (0)	0 (0)	0 (0)	0 (0)
Total	20 (100)	20 (100)	20 (100)	20 (100)

Table 10. Distribution of HSEE Science Questions in RBT.

KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	1. Remembering	2. Understanding	3. Applying	4. Analyzing	5. Evaluating	6. Creating
A. Factual knowledge	0	4	0	1	0	0
B. Conceptual knowledge	0	22	3	12	0	0
C. Procedural knowledge	0	5	10	17	3	0
D. Metacognitive knowledge	0	0	1	1	1	0

Table 10 shows which of the HSEE science questions corresponds to which level in the RBT's knowledge and cognitive process dimension and how many questions in total.

It was observed that 80 of the science questions asked in the HSEE between 2018 and 2021 corresponded the most to the B2 level (Conceptual/Understanding) with 22 questions, followed by the C4 level (Procedural/Analyzing) with 17 questions. According to the examined HSEE science questions, questions at the understanding level were used more for the factual and conceptual knowledge types, and also questions at the analyzing level for procedural knowledge types. For the metacognitive knowledge type, it can be seen that only one question was asked from the applying, analyzing, and evaluating levels.

Percentage analysis of the HSEE science questions for 2018 to 2021 according to the RBT knowledge dimension are illustrated in **Figure 3**.

When **Figure 3** is examined, it can be seen that the HSEE science questions accumulated under the conceptual and procedural knowledge types

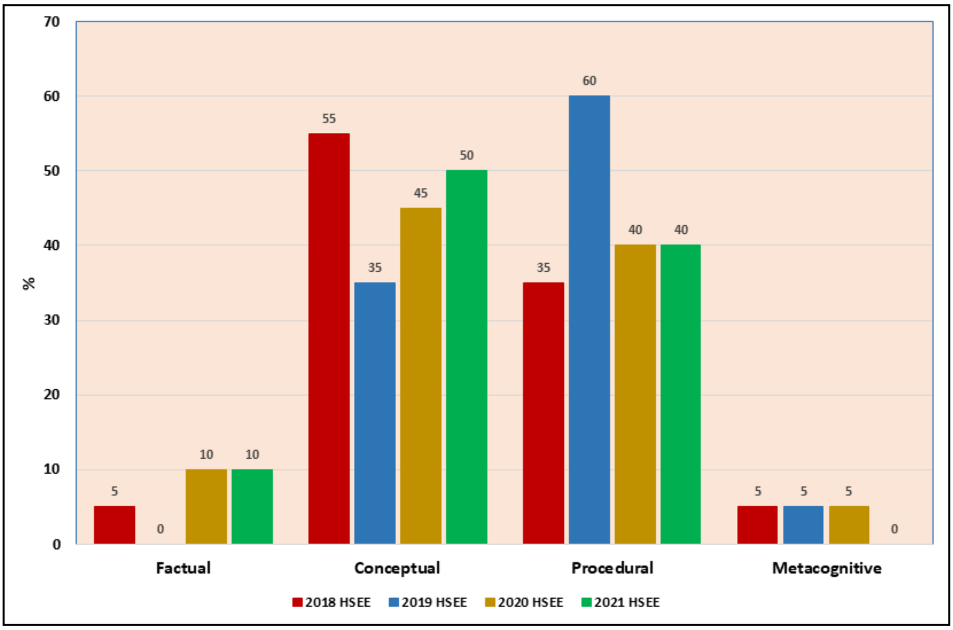

Figure 3. Percentage Comparison of HSEE Science Questions by Year for RBT Knowledge Dimension.

across all 4 years of the study data. It is noteworthy to mention here that not many questions of the factual or metacognitive knowledge types were found. While no factual knowledge type science questions were asked in the 2019 HSEE, no metacognitive knowledge type science questions were asked in the 2021 HSEE. The most science questions of the conceptual knowledge type were included in the 2018 HSEE, while the most science questions of the procedural knowledge type were included in the 2019 HSEE.

Percentage analysis of the HSEE science questions from 2018 to 2021 according to the RBT cognitive process dimension are illustrated in **Figure 4**.

When **Figure 4** is examined, it can be seen that the HSEE science questions were mostly concentrated on the understanding and analyzing levels, but that no questions were asked on the remembering or creating levels. The most science questions asked on the understanding level were from the 2020 HSEE, whilst the most asked on the applying level were from the 2018 HSEE, and the most on the analyzing level were from the 2020 and 2021 HSEE.

"To what extent are the science teachers' exam questions and the HSEE science questions compatible according to the RBT?"

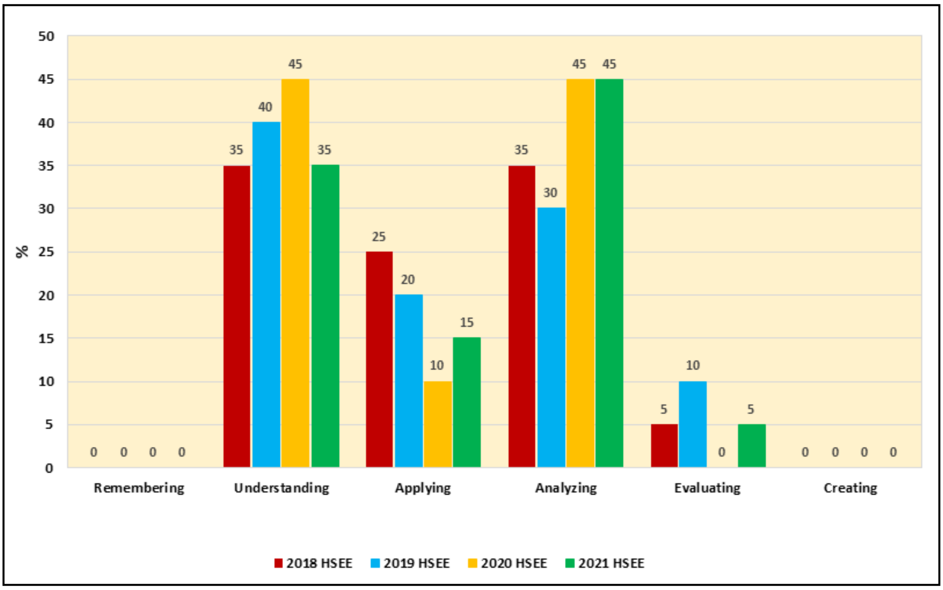

Figure 4. Percentage Comparison of HSEE Science Questions by Year for RBT Cognitive Process Dimension.

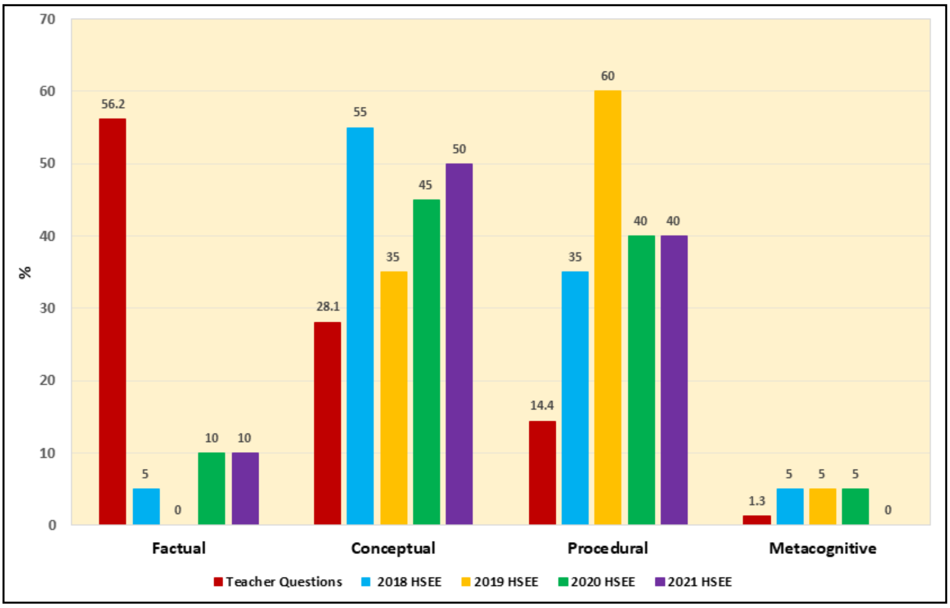

Figure 5. Percentage Comparison of Science Teachers' Written Exam Questions and HSEE Science Questions for RBT Knowledge Dimension.

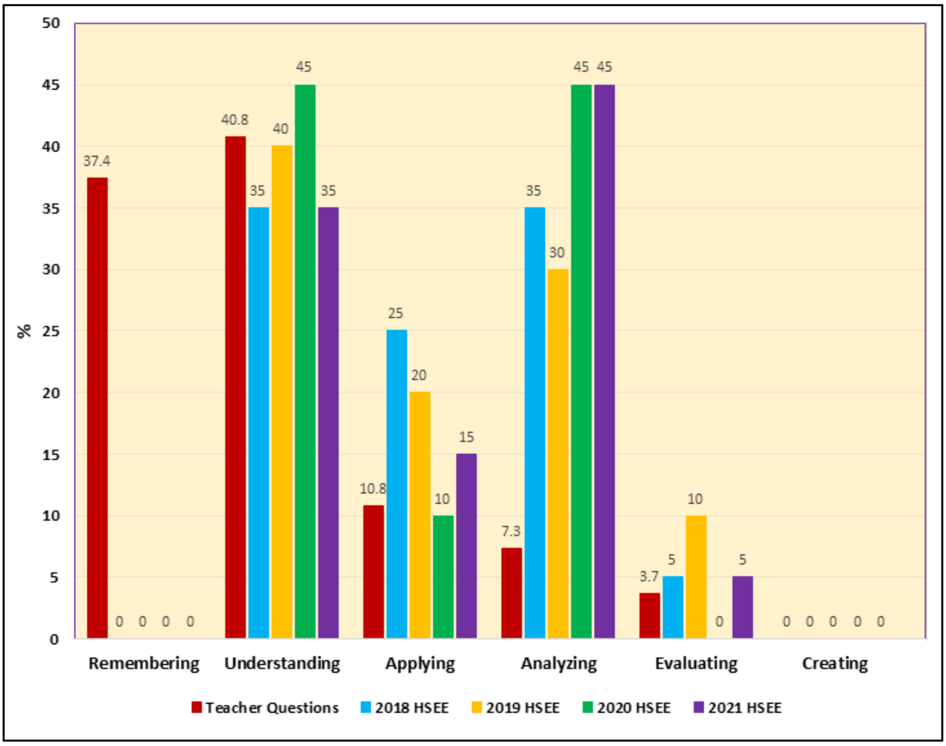

Figure 6. Percentage Comparison of Science Teachers' Written Exam Questions and HSEE Science Questions for RBT Cognitive Process Dimension.

The exam questions prepared by science teachers were compared with the HSEE science questions in terms of the knowledge and cognitive process dimensions of the RBT, and the results are illustrated in **Figure 5** and **Figure 6**, respectively.

According to **Figure 5**, when the science teachers' written exam questions were compared with the HSEE science questions, it can be seen that the science teachers' questions were mostly of the factual and conceptual knowledge type from the RBT knowledge dimension, whilst the HSEE science questions were mostly of the conceptual and procedural knowledge type. It is noteworthy to mention that the science teachers' exam questions were of the factual knowledge type with a maximum of 56.2% in the knowledge dimension. When the HSEE science questions were examined, it was seen that in 2018 they were of the conceptual knowledge type with a maximum of 55%, whereas in 2019 they were of the procedural knowledge type with a maximum of 60%, in 2020 they were of the conceptual knowledge type with a maximum of 45%, and in the 2021 the HSEE science questions were of the conceptual knowledge type with a maximum of 50%. No HSEE science questions of the factual type of information were asked in 2019, nor of the metacognitive information type in 2021.

According to **Figure 6**, when the science teachers' written exam questions and the HSEE science questions were compared according to the RBT cognitive process dimension, it was seen that 89% of the science teacher's written exam questions were at the lower cognitive levels of remembering, understanding, and applying, whilst 11% were at the higher cognitive levels of analyzing and evaluating. None of the science teachers' written exam questions were found corresponding to the creating level. It was observed that 60% of the 2018 HSEE science questions were at the lower cognitive levels (understanding and applying) and 40% were at the higher cognitive levels (analyzing and evaluating), that 60% of the 2019 HSEE science questions were at the lower cognitive levels (understanding and applying) and 40% were at the higher cognitive levels (analyzing and evaluating), that 55% of the 2020 HSEE science questions were at the lower cognitive levels (understanding and applying) and 4% were at the higher cognitive level (evaluating), and that 50% of the 2021 HSEE science questions were at the lower cognitive levels (understanding and applying) and 50% were at the higher cognitive levels (analyzing and evaluating). No HSEE science questions were found to be the remembering and creating levels in any of the 4 years analyzed.

Discussion & Conclusion

The findings obtained from the analysis of the science teachers' written exam questions according to the RBT revealed questions corresponding to each knowledge type in the taxonomy. However, the distribution of the questions across the different knowledge type was not found to be homogeneous. The science teachers' exam questions were mainly of the factual knowledge type, with a significant number of conceptual knowledge type questions. The fact that the science teachers mainly included factual knowledge questions may suggest that the teachers prefer not to take risks, as the least controversial question types are considered those that examine factual knowledge. Similar studies in the literature also support these results. In research where sixth-grade science course exam questions were analyzed according to the RBT, it was reported that the questions were mainly of the factual knowledge type in accordance with the knowledge dimension of the RBT (Ataş & Güneş 2020). The findings of a study by Ayvacı and Türkdoğan (2010) also support these results. In the current study, the science teachers used very few questions (1.3%) of the metacognitive knowledge type in the knowledge dimension; a type primarily considered as being within the affective domain. A complaint has been levelled that questions that examine the characteristics of the affective domain are not generally used in the measurement processes of exams (Tekindal 2009); a result that was also obtained in the current study.

When the exam questions prepared by the science teachers were analyzed according to the RBT's cognitive process dimension, it was found that their questions were mostly at the remembering and understanding levels, and that the proportion of questions at these levels were quite close to each other. It may be said, therefore, that the science teachers' preference for mostly remembering level questions could lead students to memorize their course content. Students who become accustomed to such question types are generally less able to achieve permanent learning, forgetting the acquired knowledge in just a short timeframe. Students with lower cognitive levels may be unable to decide how best to solve high-level questions. Similar results have been reported in previous studies on this same topic (Ataş & Güneş 2020; Dindar & Demir 2006; Karaer 2020; Tanık & Saraçoğlu 2011). Dindar & Demir (2006) found that in the fifth-grade science lessons, and also in the sixth grade according to Ataş and Güneş (2020), that teachers mainly used questions corresponding to the remembering level of the RBT's cognitive process dimension. In a study by Tanık and Saraçoğlu (2011), it was emphasized that teachers who ask questions with similar low-level thinking skills do not include many questions, especially those above the level of remembering. Additionally, Karaer (2020) analyzed organic chemistry questions in teaching field knowledge tests according to the RBT, and concluded that the questions were mostly at the understanding level in the cognitive process dimension of the RBT. Where there are considered too many problems presented in questions at the understanding level, it may not actually be a negative situation since it is believed that understanding level learning forms the basis for more advanced learning in order to ensure the permanence and transferability of what has been learned.

While the ratio of the questions asked at the applying and analyzing levels were found to be close in the current study, the number of questions asked at the evaluating level were notably very few, and no questions at all were asked at the creating level. The findings showed that the questions were stacked at the lower cognitive process levels in the exam questions prepared by the science teachers. It may be said that it is important to include more questions at the analyzing level in order for students to improve their critical thinking skills. It can therefore be considered a significant deficiency that questions examining higher-level cognitive features such as applying, analyzing, evaluating, and creating in educational environments were not adequately included in the data that was reviewed. In a study conducted by Ayvacı and Türkdoğan (2010), it was reported that teachers fail to take taxonomy into consideration when preparing written science and technology course questions, and that the distribution of questions according to the levels in the taxonomy can be quite irregular.

When the HSEE science questions were analyzed in the current study according to the knowledge dimension of the RBT, it was determined that most questions were of the conceptual and procedural knowledge type. When the percentage distribution of the 2018 HSEE science questions was examined, it was concluded that there was an excess of conceptual knowledge type questions, with only one each asked of the factual and metacognitive types. It is notable that the 2019 HSEE science questions were predominantly of the procedural information type, and that no factual information type questions were asked. It was concluded that the 2020 and 2021 HSEE science questions were mainly of the conceptual and procedural information type, and that the numbers of the questions in these two types of knowledge were very close to each other. On the other hand, only one question was found of the metacognitive knowledge type in HSEE 2020 and none in 2021. The literature shows similar findings from studies on this subject. In Çakir's (2019) analysis of TFBSE, HSEE, and PISA science questions according to the RBT, it was found that most of the 2017 TFBSE exam questions were of the conceptual knowledge type from the knowledge dimension. Similarly, Akyurek (2019) determined that the 2016-2017 TFBSE exams and the 2018 HSEE science questions were of the procedural knowledge type from the RBT's knowledge dimension. Similarly, Altun (2016) reported that the mathematics questions in the TFBSE (2014-2015) were mostly of the procedural knowledge type from the knowledge dimension.

When the HSEE science questions were analyzed according to the RBT's cognitive process dimension, it was revealed that the questions were mostly concentrated at the understanding, applying, and analyzing levels. No HSEE science questions were encountered at the remembering level, which is the lowest cognitive process level, or the creating level, which is the highest cognitive process level. The 2018 HSEE science questions were concentrated at the understanding, applying, and analyzing levels, with just one question at the evaluating level. While the 2019 HSEE science questions were mainly at the understanding and analyzing levels, two were asked at the evaluating level. The 2020 HSEE science questions were revealed to be homogeneously distributed between the understanding and analyzing levels, with no questions asked at the evaluating level. Notably, the 2021 HSEE science questions were mostly at the analyzing level. 2021 was also the year in which the most HSEE science questions were asked at the higher cognitive process level. These results can be said to be similar to the findings of previous studies in the literature. Ekinci and Bal (2019) revealed that the 2018 HSEE mathematics questions were mostly at the applying and analyzing levels in the cognitive process dimension. Similarly, Vural (2020) revealed that HSEE Turkish questions between 2010 and 2020 were at the understanding level in the cognitive process dimension, whilst TFBSE exam questions were at the analyzing level.

In the current study, the level of similarity between the exam questions prepared by the science teachers and the HSEE science questions was revealed to be very low when compared in accordance with the knowledge and cognitive process dimensions of the RBT. It was observed that the questions prepared by the science teachers were mostly of the factual knowledge type, which is the first level of the knowledge dimension, and the HSEE science questions were mainly of the conceptual and procedural knowledge types. It was revealed that very few questions were of the metacognitive knowledge type in both the exam questions developed by the science teachers and the HSEE science questions.

While the exam questions prepared by the science teachers generally consisted of the first three levels of the RBT's cognitive process dimension (remembering, understanding, and applying) that measure low-level thinking skills, an insufficient number of questions were asked from the last three levels (analyzing, evaluating, and creating) of the cognitive process dimension that measure high-order thinking skills. The HSEE science questions were found to be stacked at the RBT's cognitive process dimension's understanding, applying, and analyzing levels. It was determined that between seven and nine HSEE science questions were asked each year at the analyzing level, which measures high-level thinking skills. While there were no questions at the creating level in the exams prepared by the science teachers, it was observed that none of the HSEE questions were at either the remembering or creating levels. In particular, it was observed that the 2020 and 2021 HSEE science questions showed similarities in the RBT's cognitive process dimension; therefore, it may be assessed that the degree of difficulty of the exams held in these 2 years was similar. Accordingly, the results of the analysis of HSEE science questions compared to the exam questions prepared by science teachers can be said to not correspond to the RBT. In a study conducted by Eş (2005), it was reported that no concordance was found between the written exam questions of science teachers and the distribution of HSEE science questions to the levels in Bloom's taxonomy.

The fact that the questions prepared by the science teachers were found in the current study to be predominantly at the lower cognitive process level and the HSEE science questions at the higher level reveal a mismatch between the success of students in their written school exams and their HSEE success. In this context, it can be seen that students with a high level of school success do not achieve the desired success in the HSEE.

The current research was limited to 35 science teachers working in one province of Turkey, and with a combined total of 1,100 written exam questions devised by these teachers between 2018 and 2021 for eighth-grade students and 80 science questions asked in the HSEE over the same time period. Based on the current study's findings, changing the written school exams to include questions prepared by science teachers that cover all levels of the RBT's knowledge dimension will help students to reach the targeted goals. Science teachers must therefore work to include questions that measure the high-level skills of students when preparing written exam papers. This change is deemed very important in order for eighth-grade students to adequately prepare for sitting their centralized high school entrance exams.

The study's findings showed that the HSEE science questions examined were concentrated around certain levels of the RBT. However, including questions at every level of both the knowledge and the cognitive process dimensions of taxonomy will help to increase the content validity of the test itself. Science teachers should also be encouraged to include written exam questions according to certain standards. In this context, it would be helpful for science teachers to consider appropriate taxonomy when preparing exam questions and to ensure that the desired level of questioning is present in their exams in accordance with the taxonomy.

It is therefore considered necessary to conduct further studies to investigate the compatibility between students' science courses and their HSEE achievements. It is also important that professional development training is provided to teachers in order to create increased awareness of the significance of this link between school-based testing and centralized exams. In terms of inservice teacher training, it is suggested that it would be beneficial to include practical applications that include question preparation activities as well as theoretical information about taxonomies. In addition, the results of the current study and other similar research can be shared with teachers as part of any professional development training on this subject; an approach that may help teachers to realize the importance and relevance of improving the questions they set for school written exams.

Additionally, conducting test development activities that take taxonomies into account in undergraduate measurement and evaluation courses will provide teacher candidates with more professional skills in exam and question preparation. Teacher candidates with such skills could set an example to serving teachers when they start working in the profession. In this way, teachers could start to gain the skills necessary to create better exam questions that are a closer match to those faced by students in centralized exams such as the HSEE. It may be said that the preparation of exam questions by science teachers in accordance with the HSEE science questions is also of significant importance in helping to reduce students' exam-based anxiety.

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ORIGINAL ARTICLE

Engagement in Structured Extracurricular Activities: A Preventive Measure for Technology Addiction in Adolescents

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Abstract

Background*: Technology has been an integral part of our lives, and it has both positive and negative effects on adolescents. The engagement in structured extracurricular activities can be utilized as a prevention method for technology or internet addiction. This can channel their time and energy in the right direction and empower valuable results for youth. The present study was conducted to compare adolescents engaged in structured and non-structured extracurricular activities in terms of spending time on computers using the internet for education and entertainment.*

Methodology*: In a cross-sectional research design, the Strength and Difficulty Questionnaire was administered to a total of 124 adolescents (75 males and 49 females) to exclude adolescents with behavioral disturbances. In addition, a semi-structured interview was also used for understanding and analyzing the impacts of structured and unstructured extracurricular activities (in terms of frequency and duration).*

Results and Conclusion*: Results indicated that academic grades were highest in adolescents involved in structured extra-curricular activities. Internet use and mobile use for social purposes were found to be higher among adolescents involved in structured extra-curricular activities. Thus, active participation in structured extra-curricular activities leads to the holistic development of adolescents, better academic performance, and decreased involvement in technology.*

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Introduction

THERE are a huge number of teenagers in India. Among the 1.2 billion global adolescents, 243 million of them reside in India (Sivagurunathan et al., 2015; UNICEF report 2011, Davey & Davey, 2014), with the highest prevalence rate of 47.4% for internet addiction in India (Balhara et al., 2018).

Currently, adolescents' going out, playing, having fun, and participating in structured extracurricular activities with respect to learning desirable constructive skills have been superseded by internet and social media use. It is not only affecting their sleep, mental health, and productivity but also badly hampering their overall development (Bener et al., 2019). Using mobile devices, computers, playing videogames, and watching TV is associated with delayed bedtime and shorter total sleep time (Anderson, 2001; Hale & Guan, 2014; Levenson et al., 2016; Punamaki et al., 2007; Twinge et al., 2019). However, listening to music has beneficial effects on sleep and enables people to relax (Yamasato et al., 2020). It is essential for adolescents to listen to music and to participate in music-related activities, as it allows them to be themselves and portray a positive and favorable image to the outside world, and additionally, it also leads to satisfaction of their emotional needs (Campabell, 2007; Mohan & Thomas, 2020; North et al., 2000). According to the reinforcement theory, using different digital applications and the internet is rewarding for most individuals because of the mood-enhancing contents available on digital platforms, e.g., pornographic material, television, social media, and videogames, which create more impact than anything else (Cash et al., 2012). It enables them to engage in violence, substance abuse, and risky sexual behaviors (Rosen et al., 2014). They share all their feelings of love and hate, aggression, and violence (Tripathi, 2017) through the internet. Hence, it is highly essential to channelize their energies in a healthy direction by enabling them to participate in structured extracurricular activities, which will prevent their extensive use of the internet and enhance their academic achievement.

Structured and Unstructured Extracurricular Activity

Structured extracurricular activities are well-planned optional services that include excursions, contests, athletics, scouting, music, folklore, article writing and editing for newspapers, displays, theater, fashion shows, exhibitions, chess, tennis, basketball, fairs, creative drama, etc., which are designed and conducted in and out of school as strategic instruments to bring about positive changes in behavior (Mahoney et al., 2004; Vandell et al., 2015). Studies have suggested the negative impacts of lacking structure in extracurricular activities (Cosden et al., 2004; Fraser-Thomas et al., 2005; Mahoney et al., 2004).

Unstructured activities involve no supervision of adults, and adolescents are likely to spend their time pertaining to their interests, which could involve chatting over a phone or glancing through the internet, watching pornography, or going out and playing (Turkson et al., 2021).

Informal, unstructured extracurricular activities, if not monitored by an adult or by the school, can lead to behavioral disturbances in adolescents and influence them to be part of unwanted societal norms (Fredricks, 2006).

If the undesirable social norms remain undefined, the impact of involvement in unsupervised and disorganized behaviors can be adverse and contribute to undesirable psychosocial outcomes (Gliman et al., 2004; Mahony & Sattin, 2000). It has been discovered that participation in structured activities is strongly linked with academic performance and desirable behavior (Darling et al., 2005).

Sports and Music-Related Extracurricular Activities

Sports activities and music-instrumental activities are essential for a healthy lifestyle, as they enhance physical fitness and inoculate team spirit (MacPhail et al., 2004), and involvement in music-related activities leads to better family relations and peer cohesion (Boer & Abubakar, 2014).

Both music- and sports-related activities give adolescents an opportunity to make friendships and to enjoy and commit to the activity (Schaefer et al., 2011; Knifsend & Juvonen, 2017).

Participating in both extracurricular athletic activities and involvement in music predicts psychological benefits and is associated with positive emotional well-being in adolescents (Boer & Abubaker, 2014; Fredricks & Eccles, 2008). Furthermore, participating in extracurriculars is an important predictor of a broad set of outcomes, like psychological adjustment and educational and occupational outcomes in adolescents (Beal & Crockett, 2010).

Internet Use, Extracurricular Activities, and Academic Grades

Teenagers' have the potential to develop a social media addiction on a personal level as it involves concerns about current issues in virtual life, which at first seems relatively simple, inexpensive, and safe. However, it gradually increases emotional aloofness, lessening communication in the real world. It also obstructs the development of personality by destroying its integrity, stability, and ability to form new social experiences. For most pupils, it is crucial to prevent internet addiction, develop a realistic perspective of life, and understand where the "I" belongs (Neverkovich et al., 2018). Families with single or divorced parents, conflict between the parents, and parent-child conflict are more likely to experience addiction. Enabling them to spend less time with family members, which is linked with children's internet use (Shek et al., 2019).

Adolescents using excessive internet use have emotional problems, poor academic performance, and are very less likely to engage in extracurricular activities (Oberle et al., 2020; Sampasa-Kanyinga et al., 2019; Tsitsika et al., 2011), leading to social isolation, depression (Alimoradi et al., 2019; Esen et al., 2014; Gross, 2004; Saikia et al., 2019; Stankovi et al., 2021), and suicidal attempts for adolescents (Schen et al., 2020). On the other hand, adolescents playing videogames are less likely to spend time reading, doing homework, and spending time with their family and friends (Cummings & Vandewater, 2007).

Altogether, involving adolescents in structured extracurricular activities beneficially brings positive results (Durlak & Weisberg, 2010; Denault & Poulin, 2016; Thomson et al., 2013). Consistent involvement in extracurricular activities builds and enhances a superb connection with the way adolescents perceive themselves, which leads to better academic achievement (Broh, 2002; Zaccoletti et al., 2020), future developmental success (Balyer & Gunduz, 2012; Beal & Crockett, 2010; Busseri et al., 2006; Gardner et al., 2008; Larson et al., 2006), and life-wide learning (Thompson et al., 2013).

Given the benefits of structured sports and music activities, parents and teachers can encourage teens to pursue these activities. Therefore, this study aims to make parents and teachers aware of the benefits associated with sports and music-related structured extracurricular activities. Whether there are any differences noticed in their digital media use can be utilized as a preventive measure to avoid excessive usage of technology.

Materials and Methods

Study Design and Setting

The study was community-based and cross-sectional research conducted in Bengaluru, India. A convenient sampling method was used. Eventually, multiple group comparisons were conducted.

Participants

A total of 124 adolescents (75 males and 49 females; 47 in the sports group, 42 in the music group, and 35 in the control group) ranging in age from 10 to 16 years, English-speaking, and seeking formal school education were finally taken into the research. Initially, the Strength and Difficulty Questionnaire (SDQ) (Goodman, 1997) was given to the adolescents for screening to identify whether they had emotional and behavioral concerns. The students with scores above 21 (cutoff score) were excluded from the study.

There were two broad groups consisting of adolescents receiving formal education for their respective structured extra-curricular activities: The sports group included 47 adolescents, the music group comprised 42 adolescents, and the control group encompassed 35 adolescents with no involvement in any structured extracurricular activity. Altogether, 124 adolescents participated in the study. Written and informed consent was obtained from parents or teachers.

Procedures

Coaching classes for sports and music activities in Bengaluru were approached for the study. A sociodemographic sheet, a semi-structural interview schedule for TV videogames, mobile computers, and the internet (TVMCI), an extracurricular data sheet, and a strengths and difficulty questionnaire by Goodman (1997) were given for data collection.

Ethical Considerations

Subjects were assured that they could decline to participate in research at any given point in time. The confidentiality of the data was maintained, and their concerns or questions related to research, or their mental health were clarified.

Tools for Data Collection

Socio-Demographic Data Sheet

The socio-demographic sheet was given to the adolescents, which included details like name, age, education, address, and percentage of marks.

Semi-structural Interview Schedule: Television, Videogames, Mobile Computers, and Internet Use

The semi-structural interview schedule was basically a time use survey that included questions regarding usage of watching TV, playing videogames, mobile usage both socially and educationally, using computers at home and at school for educational purposes, and usage of the internet socially and educationally measured in terms of frequency in a week's time, like how much time usage of either of these equipments or use of the internet is present, whether adolescents are using it daily, for how much time they use, measured in terms of minutes, and also since how many months, these aspects were covered.

Extracurricular Activity Checklist (ECA)

It included questions related to the number of hours spent in the structured extracurricular activity, the duration of formal training in months, the frequency of going to the respective formal training class (number of times in a week), practice hours spent both individually and along with the trainer (number of hours), and the duration of formal training received in months (since when).

Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997)

This questionnaire is used to identify behavioral and emotional problems in children. This test consists of 25 statements, which are divided into five constructs: conduct problems, hyperactivity or inattention, emotional problems, peer problems, and pro-social behavior. There are different versions of this questionnaire for parents, teachers, and children and adolescents. A higher SDQ score is associated with greater behavioral disturbances in children. Prosocial subscale scoring is excluded from the total score. Reliability was assessed using an internal consistency mean alpha of 0.73 and a retest stability mean of 0.62. Validity was examined by investigating the correlation of the SDQ. Crossing over scores above the 90th percentile indicates diagnosable psychopathology in children and adolescents (Goodman et al., 2004). It has both parent and teacher versions, which have strong psychometric properties. (Stone et al., 2010)

Statistical Analysis

IBM SPSS software was used for analysis of the data. The sociodemographic data were distributed into 3 sub-groups, i.e., sports group, music-instruments group, and control group.

For subjective ratings of liking, achievements, amount spent, and semi-structural interview schedules for TVMCI variables, descriptive statistics such as mean and standard deviation (SD) were calculated. To explore the group differences, a One-Way ANOVA was done. To determine the significance level, a post-hoc Tukey test and Honestly Significant Difference (HSD) were conducted.

Results

There was a significant difference found in the age and education of the sports, music-instrumental, and control groups. It was seen that academic marks were found to be higher in both the sports group (mean = 86.04, SD = 8.01) and the music-instrumental group (mean = 84.12, SD = 11.35), with the lowest being in the control group (mean = 76.06, SD = 12.56) (**Table 1**).

Post hoc analysis of sociodemographic variables suggests that age, education, and academic marks were significant at the 0.05 level (**Table 2**).

Significant difference found in all three respective groups, frequency of practice was found to be (mean = 3.70, SD = 1.805), number of hours spent (mean = 3.40, SD = 1.523), amount spent (mean = 1471.28, SD = 585.58) and achievements (mean = 0.55, SD = 0.503) was found to be more in the sports group than the other two groups (**Table 3**). On the other hand, the music group had the highest subjective rating of liking (mean = 9.60, SD = 1.57) was followed by the sports group and the control group (**Table 4**).

Tables 5 and **6** show that all three subgroups differed in SDQ scores. Sports group and music group SDQ total scores were highest in comparison with the control group and pro-social behavior. Subscale scores were greater in both the music-instrumental group (mean = 7.43, SD = 2.25) and the sports group (mean = 7.32, SD = 2.24) than in the control group (mean = 6.57, SD = 2.48).

No. of times (the frequency of using the internet for social use per week) (mean = 1.03 SD = 2.269), Internet use in minutes per week (mean = 42.86, SD = 90.377) and Internet Use for Months together were found to be higher in the control group than sports and the control group (**Tables 7-9**).

Mobile use for social purposes in the sports group had higher scores in No times (frequency in week) (mean = 2.79, SD = 3.127), Mobile social (since how long) Months (mean = 9.28, SD = 16.880). However, the control group had the highest mobile use in terms of duration in minutes (mean = 36.86, SD = 83.235) (**Tables 10-14**).

The control group had the highest frequency (mean = 6.86, SD = 0.845) since the months (mean = 167.54, SD = 99.957) in comparison with all the rest of the group (**Tables 15-17**).

Discussion

Since it was a time-bound study, the number of participants was variable in each group. In this study, the duration in minutes for mobile phone use (social purpose) was found to be greater in the control group than in adolescents involved in structured extracurricular activities (**Tables 18-21**). In fact, compulsive usage of technology has become a way of life for everyone. Both adolescents and parents use it for different purposes when looking at each other. As per the social learning theory given by Bandura, modeling (vicarious learning) has taken place (Vala & Blekley, 2015). The technology has

Table 1. Demographic Characteristics of the Sample.

		Mean	Standard Deviation	F	Sig.
Age	Sports Group	12.40	2.007	4.665	0.11
	Music & Instruments Group	12.17	1.766		
	Control Group	13.54	2.501		
	Total	12.65	2.146		
Education	Sports Group	6.98	2.364	2.638	0.076
	Music & Instruments Group	6.64	2.046		
	Control Group	7.86	2.702		
	Total	7.11	2.397		
Marks	Sports Group	86.04	8.011	9.572	0.00
	Music & Instruments Group	84.12	11.353		
	Control Group	76.06	12.563		
	Total	82.57	11.317		

Table 2: Multiple comparisons Post HOC Tukey Test on Sociodemographic Variables.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
Age	Sports Group	Music & Instruments Group	0.238	0.853
		Control Group	-1.139*	0.042
	Music & Instruments Group	Sports Group	-0.238	0.853
		Control Group	-1.376*	0.013
	Control Group	Sports Group	1.139*	0.042
		Music & Instruments Group	1.376*	0.013
Education	Sports Group	Music & Instruments Group	0.336	0.782
		Control Group	-0.878	0.224
	Music & Instruments Group	Sports Group	-0.336	0.782
		Control Group	-1.214	0.068
	Control Group	Sports Group	0.878	0.224
		Music & Instruments Group	1.214	0.068
Marks	Sports Group	Music & Instruments Group	1.924	0.670
		Control Group	9.985*	0.000
	Music & Instruments Group	Sports Group	-1.924	0.670
		Control Group	8.062*	0.003
	Control Group	Sports Group	-9.985*	0.000
		Music & Instruments Group	-8.062*	0.003

Table 3. Mean, Standard Deviation and ANOVA on ECA.

		Mean	Std. Deviation	F	Sig.
Frequency of Practice	Sports Group	3.70	1.805	7.018	0.001
	Music & Instruments Group	2.29	1.019		
	Control Group	3.34	2.496		
	Total	3.12	1.915		
No. of hours	Sports Group	3.40	1.527	13.986	0.000
	Music & Instruments Group	2.81	1.890		
	Control Group	1.60	0.976		
	Total	2.69	1.693		
Since when?	Sports Group	19.26	20.655	2.321	0.102
	Music & Instruments Group	19.55	22.399		
	Control Group	10.91	14.269		
	Total	17.00	19.944		
Amount	Sports Group	1,471.28	585.583	78.556	0.000
	Music & Instruments Group	1109.81	684.136		
	Control Group	0.00	0.000		
	Total	933.56	808.297		
Subjective Rating of Liking	Sports Group	9.49	1.586	14.072	0.000
	Music & Instruments Group	9.60	1.578		
	Control Group	6.57	4.648		
	Total	8.70	3.089		
Achievements in ECA	Sports Group	0.55	0.503	18.040	0.000
	Music & Instruments Group	0.31	0.468		
	Control Group	0.00	0.000		
	Total	0.31	0.466		

immense addictive potential (Sherma et al., 2017). Even non-users are motivated to use it (Bremer, 2005; Selwyn et al., 2005; Whiting & Janasz, 2004). It is found that among adolescents in India, the use of devices for Internet surfing is 67% and WhatsApp use is 93.6%. Mobile phones in this population were discovered to be chatting and texting at 87.5 The use of mobiles after coming back from school was 57.7%; 34.6% of respondents indicated that they check their mobiles as soon as they get up from bed, and 30.9% said that they use their mobile phones for more than 4 hours (Venkataraghavan, 2015).

Adolescents involved in music-related activities prefer to spend time practicing music instead of indoor activities like playing computer games. Though outdoor activities, visiting friends, or playing their favorite sport were substantially preferred, along with participation in musical activities (North et al., 2000).

Table 4. Multiple Comparison Post HOC Tukey Test on ECA Checklist.

Dependent Variable		(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
Frequency of Practice	Tukey HSD	Sports Group	Music & Instruments Group	1.416*	0.001
			Control Group	0.359	0.654
		Music & Instruments Group	Sports Group	-1.416*	0.001
			Control Group	-1.057*	0.034
		Control Group	Sports Group	-0.359	0.654
			Music & Instruments Group	1.057*	0.034
	LSD	Sports Group	Music & Instruments Group	1.416*	0.000
			Control Group	0.359	0.380
		Music & Instruments Group	Sports Group	-1.416*	0.000
			Control Group	-1.057*	0.013
		Control Group	Sports Group	-0.359	0.380
			Music & Instruments Group	1.057*	0.013
No. of hours	Tukey HSD	Sports Group	Music & Instruments Group	0.595	0.167
			Control Group	1.804*	0.000
		Music & Instruments Group	Sports Group	-0.595	0.167
			Control Group	1.210*	0.002
		Control Group	Sports Group	-1.804*	0.000
			Music & Instruments Group	-1.210*	0.002
	LSD	Sports Group	Music & Instruments Group	0.595	0.071
			Control Group	1.804*	0.000
		Music & Instruments Group	Sports Group	-0.595	0.071
			Control Group	1.210*	0.001
		Control Group	Sports Group	-1.804*	0.000
			Music & Instruments Group	-1.210*	0.001
Since when?	Tukey HSD	Sports Group	Music & Instruments Group	-0.292	0.997
			Control Group	8.341	0.145
		Music & Instruments Group	Sports Group	0.292	0.997
			Control Group	8.633	0.140
		Control Group	Sports Group	-8.341	0.145
			Music & Instruments Group	-8.633	0.140
	LSD	Sports Group	Music & Instruments Group	-0.292	0.944
			Control Group	8.341	0.061
		Music & Instruments Group	Sports Group	0.292	0.944
			Control Group	8.633	0.058
		Control Group	Sports Group	-8.341	0.061
			Music & Instruments Group	-8.633	0.058
Amount	Tukey HSD	Sports Group	Music & Instruments Group	361.467*	0.005
			Control Group	1,471.277*	0.000
		Music & Instruments Group	Sports Group	-361.467*	0.005
			Control Group	1,109.810*	0.000
		Control Group	Sports Group	-1,471.277*	0.000
			Music & Instruments Group	-1,109.810*	0.000
	LSD	Sports Group	Music & Instruments Group	361.467*	0.002
			Control Group	1,471.277*	0.000
		Music & Instruments Group	Sports Group	-361.467*	0.002
			Control Group	1,109.810*	0.000
		Control Group	Sports Group	-1,471.277*	0.000
			Music & Instruments Group	-1,109.810*	0.000
Subjective rating	Tukey HSD	Sports Group	Music & Instruments Group	-0.106	0.983
			Control Group	2.918*	0.000
		Music & Instruments Group	Sports Group	0.106	0.983
			Control Group	3.024*	0.000
		Control Group	Sports Group	-2.918*	0.000
			Music & Instruments Group	-3.024*	0.000
	LSD	Sports Group	Music & Instruments Group	-0.106	0.859
			Control Group	2.918*	0.000
		Music & Instruments	Sports Group	0.106	0.859

		Group	Control Group	3.024*	0.000
		Control Group	Sports Group	-2.918*	0.000
			Music & Instruments Group	-3.024*	0.000
Achievement	Tukey HSD	Sports Group	Music & Instruments Group	0.244*	0.017
			Control Group	0.553*	0.000
		Music & Instruments Group	Sports Group	-0.244*	0.017
			Control Group	0.310*	0.004
		Control Group	Sports Group	-0.553*	0.000
			Music & Instruments Group	-0.310*	0.004
	LSD	Sports Group	Music & Instruments Group	0.244*	0.006
			Control Group	0.553*	0.000
		Music & Instruments Group	Sports Group	-0.244*	0.006
			Control Group	0.310*	0.001
		Control Group	Sports Group	-0.553*	0.000
			Music & Instruments Group	-0.310*	0.001

Table 5. One-Way ANOVA on Strength and Difficulty Questionnaire (SDQ).

		Mean	Std. Deviation	F	Sig.
Emotional	Sports Group	2.36	1.762	1.073	0.345
	Music & Instruments Group	1.86	1.676		
	Control Group	2.66	3.694		
	Total	2.27	2.444		
Conduct	Sports Group	2.34	1.809	0.898	0.410
	Music & Instruments Group	1.88	1.656		
	Control Group	2.26	1.559		
	Total	2.16	1.689		
Hyper Activity	Sports Group	2.87	1.884	0.132.	0.876
	Music & Instruments Group	2.76	2.093		
	Control Group	2.66	1.589		
	Total	2.77	1.869		
Peer Problems	Sports Group	2.04	2.177	0.385	0.681
	Music & Instruments Group	2.26	2.073		
	Control Group	2.43	1.614		
	Total	2.23	1.987		
Prosocial Behavior	Sports Group	7.32	2.247	1.516	0.224
	Music & Instruments Group	7.43	2.254		
	Control Group	6.57	2.489		
	Total	7.15	2.329		
Total	Sports Group	9.49	5.254	0.703	0.497
	Music & Instruments Group	8.55	5.283		
	Control Group	8.29	3.923		
	Total	8.83	4.915		

Table 6. Post Hoc Tests Multiple comparisons on Strength and Difficulty Questionnaire (SDQ).

Dependent Variable		(I) Subgroups	(J) Subgroups	Mean Difference (I-J)	Sig.
Emotional	Tukey HSD	Sports Group	Music & Instruments Group	0.505	0.595
			Control Group	-0.295	0.851
		Music & Instruments Group	Sports Group	-0.505	0.595
			Control Group	-0.800	0.328
		Control Group	Sports Group	0.295	0.851
			Music & Instruments Group	0.800	0.328
	LSD	Sports Group	Music & Instruments Group	0.505	0.333
			Control Group	-0.295	0.589
		Music & Instruments Group	Sports Group	-0.505	0.333
			Control Group	-0.800	0.155
		Control Group	Sports Group	0.295	0.589
			Music & Instruments Group	0.800	0.155
Conduct	Tukey HSD	Sports Group	Music & Instruments Group	0.459	0.409
			Control Group	0.083	0.974
		Music & Instruments Group	Sports Group	-0.459	0.409
			Control Group	-0.376	0.596
		Control Group	Sports Group	-0.083	0.974
			Music & Instruments Group	0.376	0.596
	LSD	Sports Group	Music & Instruments Group	0.459	0.203
			Control Group	0.083	0.826
		Music & Instruments Group	Sports Group	-0.459	0.203
			Control Group	-0.376	0.333
		Control Group	Sports Group	-0.083	0.826
			Music & Instruments Group	0.376	0.333
Hyper Activity	Tukey HSD	Sports Group	Music & Instruments Group	0.110	0.959
			Control Group	0.215	0.866
		Music & Instruments Group	Sports Group	-0.110	0.959
			Control Group	0.105	0.968
		Control Group	Sports Group	-0.215	0.866
			Music & Instruments Group	-0.105	0.968
	LSD	Sports Group	Music & Instruments Group	0.110	0.783
			Control Group	0.215	0.610
		Music & Instruments Group	Sports Group	-0.110	0.783
			Control Group	0.105	0.808
		Control Group	Sports Group	-0.215	0.610
			Music & Instruments Group	-0.105	0.808
Peer_Problems	Tukey HSD	Sports Group	Music & Instruments Group	-0.219	0.863
			Control Group	-0.386	0.663
		Music & Instruments Group	Sports Group	0.219	0.863
			Control Group	-0.167	0.929
		Control Group	Sports Group	0.386	0.663
			Music & Instruments Group	0.167	0.929
	LSD	Sports Group	Music & Instruments Group	-0.219	0.606
			Control Group	-0.386	0.388
		Music & Instruments Group	Sports Group	0.219	0.606
			Control Group	-0.167	0.716
		Control Group	Sports Group	0.386	0.388
			Music & Instruments Group	0.167	0.716
Prosocial Behavior	Tukey HSD	Sports Group	Music & Instruments Group	-0.109	0.973
			Control Group	0.748	0.322
		Music & Instruments Group	Sports Group	0.109	0.973
			Control Group	0.857	0.243
		Control Group	Sports Group	-0.748	0.322
			Music & Instruments Group	-0.857	0.243
	LSD	Sports Group	Music & Instruments Group	-0.109	0.825
			Control Group	0.748	0.151
		Music & Instruments Group	Sports Group	0.109	0.825
			Control Group	0.857	0.109

		Control Group	Sports Group	-0.748	0.151
			Music & Instruments Group	-0.857	0.109
Total	Tukey HSD	Sports Group	Music & Instruments Group	0.942	0.641
			Control Group	1.204	0.520
		Music & Instruments Group	Sports Group	-0.942	0.641
			Control Group	0.262	0.971
		Control Group	Sports Group	-1.204	0.520
			Music & Instruments Group	-0.262	0.971
	LSD	Sports Group	Music & Instruments Group	0.942	0.370
			Control Group	1.204	0.276
		Music & Instruments Group	Sports Group	-0.942	0.370
			Control Group	0.262	0.817
		Control Group	Sports Group	-1.204	0.276
			Music & Instruments Group	-0.262	0.817

Table 7. One-Way ANOVA on Extracurricular Activity Checklist.

		Mean	SD	F	Sig.
Frequency of Practice	Sports Group	3.70	1.805	7.018	0.001
	Music & Instruments Group	2.29	1.019		
	Control Group	3.34	2.496		
	Total	3.12	1.915		
No. of hours	Sports Group	3.40	1.527	13.986	0.000
	Music & Instruments Group	2.81	1.890		
	Control Group	1.60	0.976		
	Total	2.69	1.693		
Since when?	Sports Group	19.26	20.655	2.321	0.102
	Music & Instruments Group	19.55	22.399		
	Control Group	10.91	14.269		
	Total	17.00	19.944		
Amount	Sports Group	1,471.28	585.583	78.556	0.000
	Music & Instruments Group	1,109.81	684.136		
	Control Group	0.00	0.000		
	Total	933.56	808.297		
Subjective Rating of Liking	Sports Group	9.49	1.586	14.072	0.000
	Music & Instruments Group	9.60	1.578		
	Control Group	6.57	4.648		
	Total	8.70	3.089		
Achievements in ECA	Sports Group	0.55	0.503	18.040	0.000
	Music & Instruments Group	0.31	0.468		
	Control Group	0.00	0.000		
	Total	0.31	0.466		

Table 8. Multiple comparisons Post HOC Tukey Test on ECA Checklist.

Dependent Variable		(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
Frequency of Practice	Tukey HSD	Sports Group	Music & Instruments Group	1.416*	0.001
			Control Group	0.359	0.654
		Music & Instruments Group	Sports Group	-1.416*	0.001
			Control Group	-1.057*	0.034
		Control Group	Sports Group	-0.359	0.654
			Music & Instruments Group	1.057*	0.034
	LSD	Sports Group	Music & Instruments Group	1.416*	0.000
			Control Group	0.359	0.380
		Music & Instruments Group	Sports Group	-1.416*	0.000
			Control Group	-1.057*	0.013
		Control Group	Sports Group	-0.359	0.380
			Music & Instruments Group	1.057*	0.013
No. of hours	Tukey HSD	Sports Group	Music & Instruments Group	0.595	0.167
			Control Group	1.804*	0.000
		Music & Instruments Group	Sports Group	-0.595	0.167
			Control Group	1.210*	0.002
		Control Group	Sports Group	-1.804*	0.000
			Music & Instruments Group	-1.210*	0.002
	LSD	Sports Group	Music & Instruments Group	0.595	0.071
			Control Group	1.804*	0.000
		Music & Instruments Group	Sports Group	-0.595	0.071
			Control Group	1.210*	0.001
		Control Group	Sports Group	-1.804*	0.000
			Music & Instruments Group	-1.210*	0.001
Since when?	Tukey HSD	Sports Group	Music & Instruments Group	-0.292	0.997
			Control Group	8.341	0.145
		Music & Instruments Group	Sports Group	0.292	0.997
			Control Group	8.633	0.140
		Control Group	Sports Group	-8.341	0.145
			Music & Instruments Group	-8.633	0.140
	LSD	Sports Group	Music & Instruments Group	-0.292	0.944
			Control Group	8.341	0.061
		Music & Instruments Group	Sports Group	0.292	0.944
			Control Group	8.633	0.058
		Control Group	Sports Group	-8.341	0.061
			Music & Instruments Group	-8.633	0.058
Amount	Tukey HSD	Sports Group	Music & Instruments Group	361.467*	0.005
			Control Group	1,471.277*	0.000
		Music & Instruments Group	Sports Group	-361.467*	0.005
			Control Group	1,109.810*	0.000
		Control Group	Sports Group	-1,471.277*	0.000
			Music & Instruments Group	-1,109.810*	0.000
	LSD	Sports Group	Music & Instruments Group	361.467*	0.002
			Control Group	1,471.277*	0.000
		Music & Instruments Group	Sports Group	-361.467*	0.002
			Control Group	1,109.810*	0.000
		Control Group	Sports Group	-1,471.277*	0.000
			Music & Instruments Group	-1,109.810*	0.000
Subjective rating	Tukey HSD	Sports Group	Music & Instruments Group	-0.106	0.983
			Control Group	2.918*	0.000
		Music & Instruments Group	Sports Group	0.106	0.983
			Control Group	3.024*	0.000
		Control Group	Sports Group	-2.918*	0.000
			Music & Instruments Group	-3.024*	0.000
	LSD	Sports Group	Music & Instruments Group	-0.106	0.859
			Control Group	2.918*	0.000
		Music & Instruments	Sports Group	0.106	0.859

		Group	Control Group	3.024*	0.000
		Control Group	Sports Group	-2.918*	0.000
			Music & Instruments Group	-3.024*	0.000
Achievement	Tukey HSD	Sports Group	Music & Instruments Group	0.244*	0.017
			Control Group	0.553*	0.000
		Music & Instruments Group	Sports Group	-0.244*	0.017
			Control Group	0.310*	0.004
		Control Group	Sports Group	-0.553*	0.000
			Music & Instruments Group	-0.310*	0.004
	LSD	Sports Group	Music & Instruments Group	0.244*	0.006
			Control Group	0.553*	0.000
		Music & Instruments Group	Sports Group	-0.244*	0.006
			Control Group	0.310*	0.001
		Control Group	Sports Group	-0.553*	0.000
			Music & Instruments Group	-0.310*	0.001

Table 9. One-Way ANOVA on Internet Use for Social and Recreation Purpose.

		Mean	Standard Deviation	F	Sig.
No times	Sports Group	0.91	2.073	0.880	0.417
	Music Group	0.48	1.550		
	Control Group	1.03	2.269		
	Total	0.80	1.971		
Internet Use Social Minutes	Sports Group	13.28	32.199	4.485	0.13
	Music Group	8.57	24.151		
	Control Group	42.86	90.377		
	Total	20.03	55.232		
Internet Use Social Months	Sports Group	8.77	25.083	0.557	0.575
	Music Group	4.62	13.489		
	Control Group	6.17	13.455		
	Total	6.63	18.686		

Table 10. Multiple Comparisons Post HOC Tukey Test on Internet Use for Social and Recreation.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
No times (Frequency in week)	Sports Group	Music Group	0.439	0.549
		Control Group	-0.114	0.964
	Music Group	Sports Group	-0.439	0.549
		Control Group	-0.552	0.442
	Control Group	Sports Group	0.114	0.964
		Music Group	0.552	0.442
Internet Use Social in minutes	Sports Group	Music Group	4.705	0.911
		Control Group	-29.581*	0.040
	Music Group	Sports Group	-4.705	0.911
		Control Group	-34.286*	0.017
	Control Group	Sports Group	29.581*	0.040
		Music Group	34.286*	0.017
Internet Use Social in months	Sports Group	Music Group	4.147	0.552
		Control Group	2.595	0.810
	Music Group	Sports Group	-4.147	0.552
		Control Group	-1.552	0.930
	Control Group	Sports Group	-2.595	0.810
		Music Group	1.552	0.930

Table 11. One-Way ANOVA on Internet Use for Educational Purposes at School.

		Mean	Std. Deviation	F	Sig.
No times (Frequency in week)	Sports Group	0.30	1.140	0.841	0.434
	Music Group	0.24	0.759		
	Control Group	0.06	0.338		
	Total	0.21	0.848		
Internet Use For Education School Minutes	Sports Group	5.64	16.766	0.564	0.570
	Music Group	8.57	26.279		
	Control Group	3.43	20.284		
	Total	6.01	21.290		
Internet Use For Education School In months	Sports Group	1.91	7.089	1.971	0.144
	Music Group	6.00	18.410		
	Control Group	1.03	6.085		
	Total	3.05	12.109		

Table 12. Multiple Comparisons Post HOC Tukey Test on Internet Use for Educational Purposes at School.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
No times (Frequency in week)	Sports Group	Music Group	0.060	0.941
		Control Group	0.241	0.415
	Music Group	Sports Group	-0.060	0.941
		Control Group	0.181	0.622
	Control Group	Sports Group	-0.241	0.415
		Music Group	-0.181	0.622
Internet Use For Education School Minutes	Sports Group	Music Group	-2.933	0.795
		Control Group	2.210	0.889
	Music Group	Sports Group	2.933	0.795
		Control Group	5.143	0.546
	Control Group	Sports Group	-2.210	0.889
		Music Group	-5.143	0.546
Internet Use For Education School In months	Sports Group	Music Group	-4.085	0.249
		Control Group	0.886	0.942
	Music Group	Sports Group	4.085	0.249
		Control Group	4.971	0.171
	Control Group	Sports Group	-0.886	0.942
		Music Group	-4.971	0.171

Table 13. One-way ANOVA on Internet Use for Educational Purpose at Home.

		Mean	Std. Deviation	F	Sig.
No times (Frequency in week)	Sports Group	1.02	1.812	2.658	0.074
	Music Group	0.36	0.692		
	Control Group	1.14	2.171		
	Total	0.83	1.676		
Internet Use at Home Minutes	Sports Group	33.51	92.059	1.103	0.335
	Music Group	13.21	28.151		
	Control Group	23.71	48.147		
	Total	23.87	64.411		
Internet Use at Home Months	Sports Group	10.72	20.970	1.202	0.304
	Music Group	5.48	12.186		
	Control Group	7.20	13.081		
	Total	7.95	16.323		

Table 14. Multiple Comparisons Post HOC Tukey Test on Internet Use for Educational Purposes at Home.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
No times (Frequency in week)	Sports Group	Music Group	0.664	0.146
		Control Group	-0.122	0.942
	Music Group	Sports Group	-0.664	0.146
		Control Group	-0.786	0.099
	Control Group	Sports Group	0.122	0.942
		Music Group	0.786	0.099
Internet Use at Home Minutes	Sports Group	Music Group	20.296	0.302
		Control Group	9.796	0.775
	Music Group	Sports Group	-20.296	0.302
		Control Group	-10.500	0.756
	Control Group	Sports Group	-9.796	0.775
		Music Group	10.500	0.756
Internet Use at Home Months	Sports Group	Music Group	5.247	0.287
		Control Group	3.523	0.598
	Music Group	Sports Group	-5.247	0.287
		Control Group	-1.724	0.889
	Control Group	Sports Group	-3.523	0.598
		Music Group	1.724	0.889

Table 15. One-Way ANOVA on Computer Use for Educational Purposes at School.

		Mean	Std. Deviation	F	Sig.
No times (Frequency in week)	Sports Group	1.15	0.932	1.751	0.178
	Music Group	1.52	1.435		
	Control Group	1.06	1.162		
	Total	1.25	1.194		
Computer Use Education at School Minutes	Sports Group	44.47	41.208	0.361	0.698
	Music Group	50.48	52.809		
	Control Group	54.29	65.722		
	Total	49.27	52.679		
Computer Use Education at School Months	Sports Group	26.30	25.442	3.183	0.045
	Music Group	29.71	28.574		
	Control Group	15.77	18.810		
	Total	24.48	25.382		

Table 16. Post Hoc Tukey Test on Computer Use for Educational Purpose at School.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
No times	Sports Group	Music Group	-0.375	0.300
		Control Group	0.092	0.936
	Music Group	Sports Group	0.375	0.300
		Control Group	0.467	0.202
	Control Group	Sports Group	-0.092	0.936
		Music Group	-0.467	0.202
Computer Use Education at School Minutes	Sports Group	Music Group	-6.008	0.855
		Control Group	-9.818	0.685
	Music Group	Sports Group	6.008	0.855
		Control Group	-3.810	0.947
	Control Group	Sports Group	9.818	0.685
		Music Group	3.810	0.947
COM EDU SCH months	Sports Group	Music Group	-3.416	0.796
		Control Group	10.526	0.146
	Music Group	Sports Group	3.416	0.796
		Control Group	13.943*	0.042
	Control Group	Sports Group	-10.526	0.146
		Music Group	-13.943*	0.042

Table 17. One-Way ANOVA on Computer Use for Educational Purpose at Home.

		Mean	Std. Deviation	F.	Sig
No times (Frequency in week)	Sports Group	1.55	1.863	3.307	0.040
	Music Group	0.86	1.775		
	Control Group	0.66	1.282		
	Total	1.06	1.719		
Computer Use Education Minutes	Sports Group	49.47	74.588	4.723	0.011
	Music Group	14.88	26.880		
	Control Group	23.14	50.455		
	Total	30.32	57.108		
Computer Use Education (Since how long) Months	Sports Group	17.62	25.969	1.661	0.194
	Music Group	14.31	26.917		
	Control Group	7.89	16.449		
	Total	13.75	24.168		

Table 18. Multiple Comparisons Post HOC Tukey Test on Computer Use for Educational Purposes.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
No times (Frequency in week)	Sports Group	Music Group	0.696	0.131
		Control Group	0.896*	0.049
	Music Group	Sports Group	-0.696	0.131
		Control Group	0.200	0.863
	Control Group	Sports Group	-0.896*	0.049
		Music Group	-0.200	0.863
Computer Use Education Minutes	Sports Group	Music Group	34.587*	0.011
		Control Group	26.325	0.089
	Music Group	Sports Group	-34.587*	0.011
		Control Group	-8.262	0.792
	Control Group	Sports Group	-26.325	0.089
		Music Group	8.262	0.792
Computer Use Education (Since how long) Months	Sports Group	Music Group	3.307	0.794
		Control Group	9.731	0.170
	Music Group	Sports Group	-3.307	0.794
		Control Group	6.424	0.475
	Control Group	Sports Group	-9.731	0.170
		Music Group	-6.424	0.475

Table 19. One-Way ANOVA on Mobile use for Educational Purpose.

		Mean	Std. Deviation	F	Sig.
No times (Frequency in week)	Sports Group	1.15	2.386	2.654	0.74
	Music group	0.21	1.094		
	Control Group	0.63	1.987		
	Total	0.69	1.944		
Mobile use Education Minutes	Sports Group	11.28	29.460	0.441	0.644
	Music group	5.36	28.076		
	Control Group	9.43	33.161		
	Total	8.75	29.964		
Mobile use Education (Since how long) Months	Sports Group	8.57	20.573	3.046	0.51
	Music group	2.29	8.480		
	Control Group	2.06	6.164		
	Total	4.60	14.229		

Table 20. Multiple Comparisons Post HOC Tukey Test on Mobile Use Educational Purposes.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Std. Error	Sig.
No times (Frequency in week)	Sports Group	Music group	0.935	0.407	0.060
		Control Group	0.520	0.428	0.447
	Music group	Sports Group	-0.935	0.407	0.060
		Control Group	-0.414	0.439	0.614
	Control Group	Sports Group	-0.520	0.428	0.447
		Music group	0.414	0.439	0.614
Mobile use Education Minutes	Sports Group	Music group	5.919	6.391	0.625
		Control Group	1.848	6.720	0.959
	Music group	Sports Group	-5.919	6.391	0.625
		Control Group	-4.071	6.889	0.825
	Control Group	Sports Group	-1.848	6.720	0.959
		Music group	4.071	6.889	0.825
Mobile use Education (Since how long) Months	Sports Group	Music group	6.289	2.972	0.091
		Control Group	6.517	3.125	0.097
	Music group	Sports Group	-6.289	2.972	0.091
		Control Group	0.229	3.204	0.997
	Control Group	Sports Group	-6.517	3.125	0.097
		Music group	-0.229	3.204	0.997

Table 21. One-Way ANOVA on Mobile Use for Social Purpose.

		Mean	Std. Deviation	F	Sig.
No times (Frequency in week)	Sports Group	2.79	3.127	2.468	0.89
	Music Group	1.40	2.604		
	Control Group	1.94	3.134		
	Total	2.08	2.998		
Mobile Use Social Minutes	Sports Group	30.47	59.868	0.435	0.648
	Music Group	23.57	41.530		
	Control Group	36.86	83.235		
	Total	29.94	62.113		
Mobile Social (Since how long) Months	Sports Group	9.28	16.880	0.748	0.485
	Music Group	8.05	18.045		
	Control Group	5.14	8.869		
	Total	7.69	15.482		

Table 22. Multiple Comparisons Post HOC Tukey Test on Mobile use for Social Purposes.

Dependent Variable	(I) ECA	(J) ECA	Mean Difference (I-J)	Sig.
No times (Frequency in week)	Sports Group	Music Group	1.382	0.076
		Control Group	0.844	0.411
	Music Group	Sports Group	-1.382	0.076
		Control Group	-0.538	0.708
	Control Group	Sports Group	-0.844	0.411
		Music Group	0.538	0.708
Mobile Use Social Minutes	Sports Group	Music Group	6.897	0.861
		Control Group	-6.389	0.891
	Music Group	Sports Group	-6.897	0.861
		Control Group	-13.286	0.622
	Control Group	Sports Group	6.389	0.891
		Music Group	13.286	0.622
Mobile Use Social (Since how long) Months	Sports Group	Music Group	1.229	0.926
		Control Group	4.134	0.459
	Music Group	Sports Group	-1.229	0.926
		Control Group	2.905	0.693
	Control Group	Sports Group	-4.134	0.459
		Music Group	-2.905	0.693

Table 23. One-Way ANOVA on Television Use.

		Mean	Std. Deviation	F	Sig.
TV No times (Frequency in week)	Sports Group	4.79	2.702	10.775	0.000
	Music Group	5.98	1.828		
	Control Group	6.86	0.845		
	Total	5.77	2.182		
TV Minutes	Sports Group	49.36	34.436	0.012	0.988
	Music Group	50.21	32.685		
	Control Group	49.26	18.376		
	Total	49.62	29.885		
TV (Since how long) Months	Sports Group	100.94	120.170	4.989	0.008
	Music Group	97.50	100.882		
	Control Group	167.54	99.957		
	Total	118.57	111.838		

Table 24: Multiple Comparisons Post HOC Tukey Test on Television.

Dependent Variable	(I) Extracurricular activity groups	(J) Extracurricular activity groups	Mean Difference (I-J)	Sig.
TV No Times Frequency	Sports Group	Music Group	-1.189*	0.018
		Control Group	-2.070*	0.000
	Music Group	Sports Group	1.189*	0.018
		Control Group	-0.881	0.143
	Control Group	Sports Group	2.070*	0.000
		Music Group	0.881	0.143
Minutes	Sports Group	Music Group	-0.853	0.990
		Control Group	0.105	1.000
	Music Group	Sports Group	0.853	0.990
		Control Group	0.957	0.989
	Control Group	Sports Group	-0.105	1.000
		Music Group	-0.957	0.989
(Since how long) Months	Sports Group	Music Group	3.436	0.988
		Control Group	-66.607*	0.019
	Music Group	Sports Group	-3.436	0.988
		Control Group	-70.043*	0.015
	Control Group	Sports Group	66.607*	0.019
		Music Group	70.043*	0.015

In the current study, it was found that adolescents involved in music-related activities and adolescents involved in sports activities spent less time watching TV, playing videogames, and using mobile devices than the control group (**Tables 22 and 23**).

Adolescents involved in structured extracurricular activities associated with sports and music have greater self-esteem, self-concept, and psychological wellbeing in comparison with adolescents not involved in any structured extracurricular activities (Pol & Roopesh, 2016). Participation in extracurricular activities also leads to better academic achievement (Camp, 1990; Craft, 2012; Darling et al., 2005; Moriana, 2006), and excessive use of media negatively affects academics (Anderson, 2001). Current study findings suggest that academic grades were found to be lower in teens, especially those who are not engaged in any organized extracurricular activity, than in structured extracurricular activity groups (**Table 1**).

Apart from academics, motivation and enthusiasm behind extracurricular activities play an essential role and are associated with successful skill development (Acar & Gunduz, 2017). The current findings suggest that subjective ratings for liking and achievements for music-related activities and sports-related activities were higher than those of adolescents not engaged in any extracurricular activity (**Table 3**).

Nonetheless, there are certain advantages associated with mobile, including the use of computers and the internet, which can be utilized for educational purposes (Nah et al., 2008; Papastergiou, 2009; Rutten et al., 2012; Sarrab, 2013).

The present study elucidates that internet use at school for educational purposes was higher in the sports and music groups than in the control group (**Table 11**). But internet use for recreational and social purposes was greater in the control group than in the sports and music groups (**Table 9**). The mobile use, computer use, and internet use at home for educational purposes scores were higher for the sports group and control group than for the music group (**Tables 11, 15, 17, and 19**).

It is found that teenagers are spending less time watching movies on TV and reading books instead of preferring to spend time on digital media (Twenge et al., 2018). But the current study states that adolescents from all three groups spend their time watching TV the most, in comparison with playing videogames and using mobile computers for both social and educational purposes (**Table 24**).

There were a few common habitual patterns observed in the sample. For all three sports groups, the music group, and the control group, the use of the internet for educational purposes was greater at home than at school; perhaps this could be due to fixed class hours. In addition, some contradictory findings were observed in all three sports groups, the music group, and the control group with reference to spending time on mobile. Using mobile socially for recreational activities was found to be higher in all groups than spending time on mobile for constructive educational activities. The results altogether suggest that technology is not being used constructively by youth; however, participation in structured extracurricular activities can help adolescents use their time wisely.

Research suggests that parental rules regarding the content of internet use may assist in avoiding compulsive use of the internet (van Den Eijnden et al., 2010). Supervision by parents plays an important role in the usage of the internet and motivating children to engage in extracurricular activities, as it can prevent internet addiction (Lin et al., 2009).

The study has direct implications for schools and mental health programs. It gives us a better understanding of adolescents' development and outcomes regarding their sociability, interpersonal relations, emotional problems, academics, and technology use.

Conclusively, it was seen that technology use for recreational purposes was found to be greater in adolescents not involved in structured extracurricular activities than in those involved in music and sports-related structured extracurricular activities. Hence, enrolling adolescents in structured extracurricular activities is beneficial for their holistic development and can prevent them from excessive technology use.

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ORIGINAL ARTICLE

Protocol-Guided Teaching in Junior-Secondary Physics Education: An Analysis of the Learning Protocol for the Velocity Instruction Based on Real-World Circumstances

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Abstract: *Protocol-guided teaching is a student-centered instructional model in which the teacher creates the learning protocol prior to the lesson in order to direct students toward active and autonomous learning. A well-structured learning protocol is essential for the effective application of this instructional paradigm. This article evaluates the significance of protocol-guided instruction in junior secondary physics education by analyzing the learning protocol for velocity instruction. Protocol emphasizes situation-based learning and the inquiry chain method.*

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Conflict of Interests: *None*

The Compulsory Education Course Standards for Physics 2022 emphasize the necessity of learning physics through inquiry based on real-world situations in order to develop key competencies in scientific explorations (Ministry of Education, 2022). To implement the new educational concept of the revised national curriculum program, a student-centered instructional strategy is required. Protocol-guided instruction is an instructional paradigm in which teachers create student learning protocols in advance based on course standards, textbook content, and student learning conditions. These protocols typically include learning objectives, materials, methods, and procedures to help students engage in more independent learning (Wang, 2022). Learning protocols must be well-designed for the protocol-guided teaching model to be implemented effectively.

This article is an analysis of the learning protocol for the velocity lesson, which uses the "Four Steps of Guidance" method of protocol-guided instruction to guide students through the entire learning process, including student preparation before class, classroom inquiry, summary and reflection, and instructional assessment (Wang & Zhu, 2023). Each component of the protocol for learning serves a distinct design purpose. The pre-class learning protocol suggests a variety of introductory activities to help students integrate into learning contexts and generate queries for future explorations. To assist students in addressing queries posed both before and during class, a detailed plan for classroom inquiry activities is developed. The subsequent step of summary and reflection aids students in generalizing research methods and building knowledge structure. Through evaluations, the instructional assessment process aims to deepen students' conceptual comprehension, solidify their mastery of knowledge and skills, and expand their competencies.

In the unit on motion, which follows those on sound, light, and heat, students are instructed to examine the tangible motion of objects. The lesson on velocity, which is the first section of this course, is comprised of multiple components and is relatively abstract. It includes the development of the concept of velocity, basic calculations using the velocity formula, and the measurement of velocity, establishing the groundwork for the study of other motion-related topics.

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Before-Class Preparation

When creating the pre-class learning procedure, authentic situations are used to introduce the lesson.

Understanding the Learning Objectives of this Lesson

i. Learn the definition and units of velocity through the ratio definition approach and learn how to compare the speeds of motion of objects through experiments. Understand that velocity is a physical quantity that describes the speed of a moving item.
ii. Conduct experiments to learn how to measure velocity.
iii. Use the velocity formula to do basic calculations in relevant exercises.

(*This approach has the dual objectives of emphasizing the subject of this session, namely the building and comprehension of the notion of velocity, and of providing students with a fundamental understanding of the learning materials and procedures of this lesson.*)

Pre-Class Learning Tasks

i. Initial estimation of velocity (by viewing a race on video or recreating a race): How do you evaluate the running speeds of the runners in the 100-meter race once the starting gun has been fired? How do the referees' running times compare?
ii. Before class, go over the material in the textbook, and get two paper cones ready as needed.
iii. Complete the exercise below,

Student X estimates that he typically walks at 1.2 meters per second, or _________ kilometers per hour; X's residence is 720 meters from school. She has to leave home at least how much time in advance to arrive to school on time? (Note the contrasts between the physics calculation format and the one used in mathematics in your writing.) _______________

iv. Ask questions concerning velocity in light of all pre-class assignments.

(*The pre-class activities are structured with the lesson's learning objectives in mind. Students work independently to study textbook material and execute preliminary experiments to encourage deeper thought under the direction of the learning protocol. The purpose of task one is to help students develop a* *perceptual awareness of the two ways to compare the velocities of moving objects: one is to look at the time required to travel a distance, and the other is to consider the distances reached in a given amount of time. Students can experiment with the two paper cones before class to gauge their speeds when falling from various heights as well as prepare them for use in the classroom inquiry. Since students have had trouble converting between composite units, Task 3's first question is designed to test their prior understanding of the relationships between various velocity units. As this is the first-time students have encountered calculation questions in junior secondary physics instruction, the second question in task three assesses students' comprehension of the accepted practices for solving calculation problems following textbook section readings. The stage of pre-class preparation involves students coming up with a range of velocity-related queries. Some of these are utilized in class as introductory questions and happen to be about the main points of this lesson. This fosters students' initiative in their academic work.)*

Classroom Inquiry

In the textbook section on velocity, there are four main objectives that stand out: teaching students to compare rates of movement; formulating the concept of velocity based on the comparison method, understanding the meaning of velocity, and learning to convert between different units of velocity; learning to measure the velocity of objects by experiment and mastering the techniques of experimental operation, table design, data processing, etc.; and following the standard steps for solving calculation problems. The learning protocol suggests a "question chain" and accompanying activities for classroom inquiry in accordance with the requirements highlighted in the textbook.

Question 1: How can the velocities of the descending paper cones are compared?

Activity one: Watch the video of renowned Chinese hurdler Xiang Liu in action.

Activity two: Experiments were conducted to compare the falling velocities of two paper cones with differing vertex angles.

- Experiment one: simultaneously drop two paper cones from the same height and compare their falling velocities.
- Experiment two: simultaneously release them from different heights and compare their velocities.

- Derive the methods for comparing the velocities of various objects from the experiments:

(*By observing real-world videos and engaging in hands-on experiments, students gain an understanding of velocity and the two preliminary methodologies for comparing velocities.*)

Question two: What quantities are employed to describe velocity in physics?

Activity: Group discussions on the significance, definition, calculation formula, and units of velocity including unit conversion.

(This activity will allow students to establish the concept of velocity through group discussions, develop a mathematical model for velocity, and comprehend the units of velocity via a formula.)

Question three: How to measure the velocity of the descending paper cone?

Activity: Measure the velocity of the falling paper cone.

- Pre-experiment preparation: defining the experiment's principle and physical quantities to be measured, preparing experimental equipment, and designing tables for recording experimental results.
- Conduct experiments in groups, document the quantities measured in the tables, and calculate the falling paper cone velocities.
- Reflections: (i) Is it preferable to begin measuring the falling time of a paper cone from the apex or the base? (ii) Is it better to measure the cone's travel time over a lengthier or shorter distance? Why? (iii) Is it more favorable to use the paper cone with a smaller or larger vertex? Why?

(*Measuring physical quantities is a fundamental skill for students to master in physics teaching. This project is designed to teach students how to measure the velocity of objects, which will be useful in their future academic lives and employment. The three reflection questions are designed to get students thinking about how to increase measurement accuracy.*)

Question four: How to solve simple calculation problems with the velocity formula?

Activity: **Figure 1** depicts a car's position as it travels down the Shanghai-Nanjing Expressway. At its current speed, how long does it take the automobile to reach Shanghai?

Hints: The velocity indicated on the dashboard is ________________.
"180 km" represents _________________________.

Figure 1

(*The purpose of this procedure is to teach students the standard methods for solving physical calculation problems.*)

Teaching Challenges:

It is challenging for students to precisely gauge the speed at which the paper cone is falling. Without guidance from the teacher, students might use the height of their desks to determine the distance, which could lead to large inaccuracies in velocity because of erroneous time measurements. The teacher used PVC pipes that she found on a construction site to create two and a half meter long "rulers" marked with 1-, 1.5-, and 2-meter indicators (as shown in **Figure 2**), allowing students to measure time based on the proper distances and ensuring the accuracy of the paper cone's velocity measurement results.

The teacher can also use images and videos to improve students' comprehension in order to maximize their guiding responsibilities in addressing students' learning issues. To demonstrate the various approaches for comparing the velocities of falling paper cones, **Figure 3** might be used as an example. **Figure 3 (a)** depicts the simultaneous release of two paper cones from the same height and the time it takes for them to fall to the ground (highlighting the same height of descent); **Figure 3 (b)** illustrates the

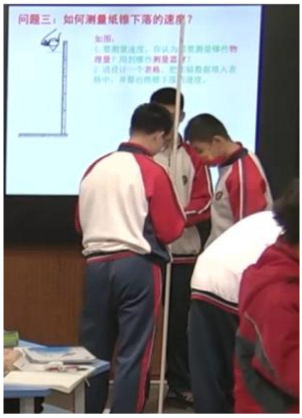

Figure 2

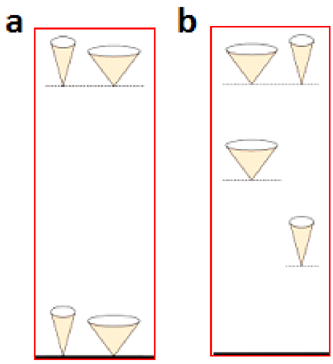

Figure 3

Figure 4

simultaneous release of two paper cones from the same height, but with different distances of movement that are noted and compared at specific points.

The “question chain” is a useful tool for helping students conceptualizes velocity. The foregoing four questions relate to students’ investigative experiences: (i) Identifying phenomena - experimenting with various techniques for measuring speeds and observing the prevalence of velocity across media (Students are shown images like **Figure 4** to remind them that velocity actually affects every aspect of their daily lives.); (ii) Understanding the concept - formulating a mathematical model for velocity and using the ratio of distance to time to describe velocity; (iii) Researching like an expert - accurately measuring velocity; and (iv) Learning to solve velocity-related calculation issues by using the formula of velocity. The student-centered teaching concept is closely associated with this type of question-oriented learning. The teacher and students can connect and conduct pertinent talks based on the “question chain” to work through challenges together. Through individual research, peer interaction, and instructor assistance, students are likely to develop a thorough comprehension of subjects and learn new approaches to problem solving.

Summary and Reflection

The purpose of the summary and reflection procedure is to encourage students to assess their classroom inquiry activities and independently construct their own velocity knowledge framework. This procedure’s learning protocol stipulates the following requirements,

i. Describe three methods for comparing the velocities of distinct objects: the amount of time spent on the same distance, the distances travelled in the same amount of time, and the calculated velocities.
ii. Generalize the principle ($v= s/t$) for calculating the velocities of falling paper cones and measurement steps.
iii. Create a knowledge framework of velocity, as shown in **Figure 5**.

Instructional Assessment

To evaluate teaching and learning outcomes, the learning protocol provides exercises of varying levels of difficulty based on instructional objectives and content.

*Exercise one: Determine the method used to compare velocities by carefully examining pictures A and B. (**Figure 6**)*

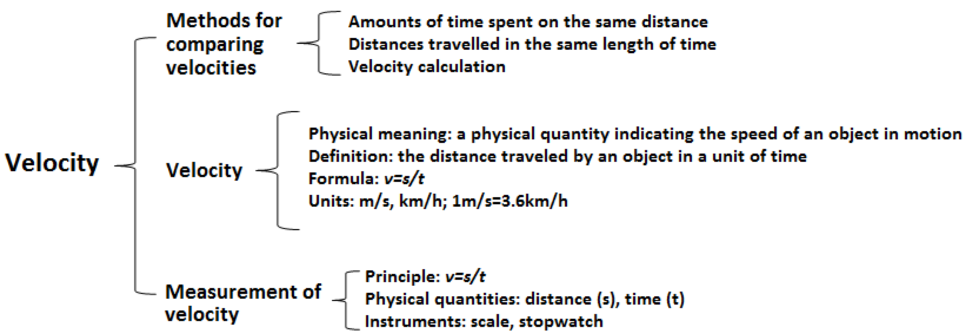

Figure 5. An Example of Students' Knowledge Framework of Velocity.

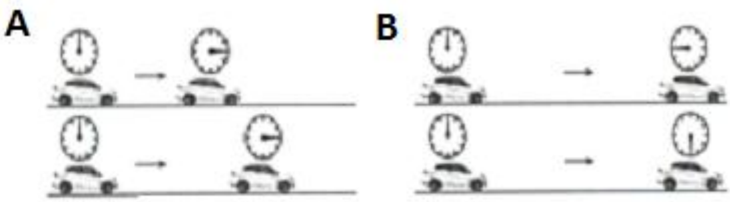

Figure 6

Exercise two: The cheetah can run at speeds of up to 30m/s on land, the sail-fish can swim at speeds of up to 100km/h in the ocean, and the swift can fly at speeds of up to 3km/min in the air. Which animal is the quickest on the planet?

*Exercise three: The Shanghai-Nanjing expressway's speed limit is indicated by a road sign. The electronic toll collection system maintains a record of a vehicle's entry onto the expressway from Suzhou at 9:00 a.m. and egress from the expressway in Shanghai at 9:40 a.m. Suzhou and Shanghai are separated by 84 kilometers. Is the motorist subject to a speeding fine? Why? (Answer the query using the standard methods for solving the calculation problems.) (**Figure 7**)*

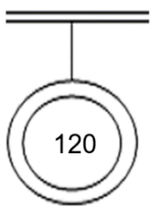

Figure 7

*Exercise four: The accompanying table is a screenshot of a record from Student M's mobile app detailing a jog he completed. It indicates that he completed the ____ km of trek in ____ minutes and that his average step length was ____ meters. (**Table 1**)*

Table 1	
2,250 Total steps	150 Step frequency: Numbers of steps/min
8.10 Speed: km/h	124 Kilocalories burnt

Exercise Five (after-class assessment):

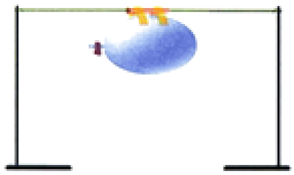

Figure 8

*Make a "jet rocket" by following the specified steps (**Figure 8**):*

- *Inflate a balloon with air, then clip it closed.*
- *Use tape to attach a little piece of straw to the balloon.*
- *Insert a piece of string through the straw, smooth it out, and then unfasten the sealing clip to cause the balloon to move. Please gauge the speed of this "jet rocket."*

(Exercises one, two, and three are fundamental queries used to assess students' mastery of fundamental velocity knowledge. The fourth exercise is more challenging and necessitates a higher level of physical aptitude, as it entails not only velocity formula-based calculations but also an analogy between velocity and step frequency. Exercise five is designed to hone students' experimental operation skills. All of these exercises are applicable to real-world situations; consequently, they have the potential to pique students' interest in further investigating velocity-related issues in daily life.

Conclusion

The learning protocol for this lesson follows the essential principles of the protocol-guided teaching paradigm, making it feasible to deliver instruction that is focused on the needs of each individual learner. The concept of "physical research deriving from lives and contributing to the society" can be better understood by students through learning activities based on real-world situations. This effectively increases their engagement in classroom inquiry and fosters their enthusiasm for physics study. The findings of both formative and summative assessments demonstrate that students can successfully complete learning goals with the aid of the learning procedure. However, there is still opportunity for advancement in both its conception and execution. Only a few of the questions brought by students can be thoroughly discussed in class due to time restrictions. To foster their spirit of exploration, more answers should be provided to their queries. Classroom experimentation with measuring velocity shows that the use of more sophisticated digital technology would aid in improving the accuracy of experimental results, suggesting that future learning protocols should place more emphasis on the improvement of digital literacy in both the teacher and students for a more successful digital-era physics education.

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REVIEW

Ethics of Artificial Intelligence in Education: Student Privacy and Data Protection

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Abstract: *Rapid advances in artificial intelligence (AI) technology are profoundly altering human societies and lifestyles. Individuals face a variety of information security threats while enjoying the conveniences and customized services made possible by AI. The widespread use of AI in education has prompted widespread public concern regarding AI ethics in this field. The protection of pupil data privacy is an urgent matter that must be addressed. On the basis of a review of extant interpretations of AI ethics and student data privacy, this article examines the ethical risks posed by AI technology to student personal information and provides recommendations for addressing concerns regarding student data security.*

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Conflict of Interests: *None*

ARTIFICIAl intelligence (AI) has emerged as a key technology in the industrial transformation of the next generation by integrating a large number of new technologies and theoretical accomplishments. AI can perform intelligent screening of educational information and scenario reproduction, automated recognition and response to fuzzy learning tasks, and neural network simulation of human brain operation mechanisms with the assistance of speech recognition, computer vision, and natural language processing enabled by intelligent analytics. The application of AI can significantly enhance the efficiency and effectiveness of education, fostering intelligent education and interactive learning. Nonetheless, amidst the rapid development of intelligent processing technology, privacy infringement and data leakage risks emerge, posing grave threats to the security of student personal information, such as the disclosure of personal information due to the "secondary exploitation" of students' private data and network frauds caused by data trafficking. Problems such as the insufficient privacy protection system and the monopoly of network technologies have become increasingly threatening, necessitating research into the ethical risks of AI to student data security.

Interpretations of AI Ethics and Student Data Privacy

Ethical Principles Underpinning AI

The ethical risks associated with AI have attracted the attention of governments, organizations, and academics from various nations, prompting in-depth reflections on the relationship between humans and technology. The "*Ethical Rules for New-generation Artificial Intelligence*" released by the Ministry of Science and Technology of China in 2021, for instance, emphasized that the use of AI must contribute to maximizing human well-being. Identifying the ethical principles underlying AI technology is essential for mitigating its dangers to humanity.

Protection of Fundamental Human Rights and Dignity

As stated in UNESCO's *Recommendation on the Ethics of Artificial Intelli-*

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gence, it is crucial for AI systems to respect, safeguard, and advance human rights, fundamental freedoms, and dignity at all stages of their development (UNESCO, 2022). AI technology offers several benefits to society, including the potential to free people from boring and repetitive work and the ongoing improvement of their decision-making and problem-solving skills. However, it is crucial that human beings always come first in the creation of AI and that their individuality is never infringed upon. Users of AI technologies should have enough autonomy to protect and support their individual rights and freedoms. Furthermore, it is crucial to safeguard human agency and refrain from objectifying people in any way that compromises their dignity in the context of the popularization of intelligent functions such as automated processes and tailored recommendations. People should still have the chance to develop the qualities essential to humanity and grow into their full potential.

Right to Privacy and Data Protection

The right to privacy is crucial to the protection of human dignity, autonomy, and agency. AI technology is based on the collection of vast volumes of data in all of its subfields. It is critical that data processing and consumption adhere to the notion of privacy and security. The retention period of information has been greatly expanded thanks to the Internet. As a result, data for AI systems must be gathered, used, shared, stored, and removed in accordance with information security standards. Personal information involved in the lifespan of AI technology should be safeguarded by legal frameworks as well as ethical norms. To ensure informed consent for data usage, personal information must not be collected, used, or disclosed without the approval of the data subjects (UNESCO, 2022).

Responsibility and Accountability

All AI actors are held accountable for the protection and promotion of human rights and dignity and are required to assume their respective ethical and legal responsibilities based on their positions in the lifecycle of the AI system's decisions and actions. To ensure accountability for AI systems and their effects, appropriate oversight, impact assessment, and due diligence evaluation should be developed.

In the midst of the present surge of expedited advancement in the field of artificial intelligence, the technology is progressively being assimilated and implemented across various domains. The emergence of machines that resemble humans has presented a novel challenge in determining accountability (Zhang, 2022). Educational AI holds promise for enhancing school management and services, optimizing instructional efficacy and results, and fostering self-development among students. Notwithstanding the advantages of AI applications, it is imperative to acknowledge the underlying concerns pertaining to accountability. Within the conventional educational framework, communication between teacher and student is a bilateral exchange that encompasses emotional interactions. When utilizing educational AI tools like intelligent guidance systems and intelligent learning partners, students can receive prompt feedback on their learning outcomes through self-assessment. However, these automated responses may not provide sufficient encouragement for students who are less academically resilient and lack self-motivation. The implementation of machine assessment and its automated marking feature has proven advantageous in enhancing the efficiency of teachers. However, in the event of marking errors, who bears the responsibility for such inaccuracies? The inquiry pertains to whether the individual in question is the programmer or the user. It is imperative to address such concerns within legal and ethical paradigms to ensure the sustainable advancement of educational AI.

Studies have examined AI ethics from a variety of perspectives. Regarding risks of AI, Zhao et al. (2021) asserted that current AI ethical concerns are primarily over issues such as undermined human decision-making autonomy, privacy protection, social equity, security responsibility attribution, and ecology, whereas Tan and Yang (2019) argued that risks of AI technology arise from the black box of algorithms, the difficulty in balancing value rationality and instrumental rationality, and the limitations of humans in risk perception and decision making. Existing research on the ethics of AI applications has examined topics such as the attribution of responsibility for intelligent driving (Si & Cao, 2017), the judicial fairness of intelligent justice (Luo & Li, 2021), the “information cocoon” effect in information push services (Peng, 2020), and the dignity of elderly individuals under robot care (Sharkey, 2014). Algorithms are the driving force behind the development of artificial intelligence. In the age of algorithms, issues such as the leakage of private information, asymmetric power of knowledge, covert operations, and algorithmic infringement are inevitable, according to Guo (2021). Decision-making based on algorithms may exacerbate inequality, opaqueness, and manipulation in human society. As for the governance of ethical issues in artificial intelligence, existing research has proposed mitigating measures from the perspectives of public policies, technological optimization, human-machine relationship modification, etc. Xue and Zhao (2019) proposed that the government should establish agile governance-based frameworks for the development and supervision of AI and other emerging industries; Jia and Jiang (2017) mentioned that the AI era’s effective public policy making depends on improved algorithms and data governance frameworks, social governance mechanisms, and global governance systems.

Hao et al. (2019) proposed that the implementation of educational AI technology and systems should prioritize student-centered education and encourage collaboration between educational actors and machines. This approach can effectively support the digital transformation of education. The significance of the association between educational agents and educational AI is underscored by Liu et al. (2021) as a crucial element of research on ethical considerations regarding educational AI.

Student Data Privacy

Privacy is commonly viewed as the right of individuals to maintain a personal space free from interference or invasion by other individuals or entities. Clarke (1999) divides privacy into privacy of the person (concerning the physical integrity of the individual), privacy of personal conduct, privacy of personal communications, and privacy of personal information. Data privacy refers to the claims of individuals that information about them should not be accessible to other individuals and organizations and that when data is in the possession of a third party, the individual must have the right to control the data and its use.

The proliferation of the Internet and big data, coupled with the growing prevalence of online academic, social, and personal activities, has led to a significant increase in the volume of private information that is being uploaded to and stored by various platforms. This includes basic personal information, such as name and mobile phone number, which is required to access a platform, as well as personal computer information, such as IP address, which is recorded by the browser. Additionally, interactive behavior information, such as browsing history and purchase records, is being retained on the Internet. Although media and platforms may anonymize collected private information to generate data that does not disclose personal identity, big data mining and analytics can still make relevant personal data accessible, thereby enabling the direct or indirect identification of specific individuals. The unauthorized acquisition and exploitation of said information by external entities or individuals may result in significant detrimental effects on the well-being of the individuals whose data is concerned.

The capacity of AI systems to identify information about student users has significantly increased in the educational setting thanks to improved intelligent processing technology and the proliferation of big data applications, and the security boundary of personal information privacy is becoming more and more blurred. Private student information includes data traces left over from the online learning process, like network browsing history, download history, and location, among other things. Learning status, behavioral preferences, and even personality features of specific students may be able to be extracted from these data through intelligent collection and analysis, which are essential elements of student data security.

The preservation of people's data privacy has been a focus of policymaking and scholarly research since information about students' learning behavior is "semi-transparent" due to the usage of intelligent learning analytics. The phrase "right to be forgotten" was first used in Europe (Shi & Zhou, 2022). More recently, in 2018, the strict *General Data Protection Regulation* was updated, emphasizing the right of data subjects to request that data controllers delete their personal information in certain situations (Hoosnagle et al., 2019). In order to improve the security of student data in use, Zhao and coworkers (2016) investigated the problem from a technical perspective and recommended developing privacy protection frameworks in the processes of data collection, data processing, and data application. The establishment and operational procedures of agencies for student privacy protection are outlined in Wang's (2016) study of the legislative and governance structure of educational privacy regulation in the United States.

Current Challenges in the Protection of Student Data Privacy

Schools, teachers, and students become the primary producers of copious amounts of private data in digital formats as a result of the digital transformation of education, but they have little autonomy over this data. As a result, there are serious issues with protecting student privacy because vast amounts of educational data are instead controlled and in the possession of third-party institutions, with schools, teachers, and students acting as simply passive data suppliers.

Increased Risks of Information Monopoly by Intelligent Educational Platforms

Educational platforms of major Internet corporations, including open online course platforms such as Coursera, Udacity, and EdX, store and keep data from educational actors. The inclination of these technologically and financially privileged Internet businesses towards data monopolies is cause for alarm. Since mining processing and subsequent correlation analysis of personal data have become major means of creating value, online educational services tend to prohibit users from modifying standard data formats or structures with the goal of acquiring user information resources. Following extensive processing, student information obtained by these businesses may be turned into data that differs from its original form and used for other profit-seeking or even criminal purposes. Edmodo is a startup that provides communication, collaborative learning, and course guidance platforms for students and teachers through educational technology. Its application was named one of the "Top Apps for Teachers" by PC Magazine (Thongmak, 2013), and it claimed to have more than 78 million users globally as of July 2017. The platform's built-in Double-Click advertising service was discovered to be capable of intelligently tracking user data flow, including web pages browsed, time spent on the website, IP addresses, and e-mail addresses, in the same year. These data, once analyzed, could be used to identify more personal information about the user. As a result, information monopolies not only hinder data sharing by erecting data barriers and divisions, but they also severely limit students' control over their personal information.

Breaches of Educational Data Security Due to the Lack of Privacy Protection Regulations

The process of digitization confers digital characteristics on the human experience. In the current era of AI, the interconnectedness of all entities and the coexistence of humans and computers have led to the ubiquitous documentation of individuals' conduct within data network systems. According to Jiang (2019), the pervasive nature of surveillance poses potential risks to the privacy of both teachers and learners.

As an emerging technology, AI is constantly evolving, which means its applications may be susceptible to a variety of vulnerabilities. Security issues with "3D" facial recognition systems, fingerprint recognition systems, and other management-related application systems, as well as the prevalence of data system hacking, have prompted extensive public debates. AI applications such as smart headbands and facial recognition check-ins have raised grave concerns regarding the security of student data in the educational setting. In spite of the fact that AI educational technology enables personalized education, the risk of data breaches and associated dangers will increase substantially as both things and people become data generators and media.

Given that data can be used as resources and instruments to pursue profits, relevant entities may violate educational ethics by misusing data to maximize its value. In contrast to explicit phenomena of infringement, black box algorithms in the AI era (Audet et al., 2016) have the potential to embed discrimination and infringement into decision-making automatically. Routine algorithmic discrimination, information control, and invasions of privacy will result in institutionalized violations. In scenarios involving AI in education, teacher and student data are not only crucial for educational decision-making but also have substantial commercial value. The data monopoly of educational platforms can lead to the exploitation of instructor and student data for profit-driven, non-educational purposes.

Deviation from the Original Intention of Informed Consent

In the traditional information society, the notice-and-consent mechanism ensures that data subjects have the autonomy to determine by who and how their private information is processed. The "notice-and-consent framework," such as the EU's Data Protection Directive, stipulates that system developers must embed privacy statements into the application system when designing the software to inform the user what data will be collected and for what purpose, and to allow the user to decide whether or not to authorize the use of their personal information (Cate & Mayer-Schonberger, 2013). Nonetheless, as a result of AI technology, the flaws of this practice are becoming increasingly apparent. Users of AI educational technology are typically required to consent to the privacy policy in order to access the corresponding software, which violates their right to autonomy. In addition, students find the concept of informed consent to be an intolerably time-consuming burden. Typically, software developers generate lengthy and obscure privacy statements in order to comply with legal requirements. In the majority of instances, students tend to disregard the detailed provisions of the privacy statement and instead select "I agree" to save time, contrary to the original intent of the notice-and-consent framework.

Strategies for Protecting Student Data Privacy

Optimizing the Regulation of Personal Data Usage

In the creation of data privacy protection frameworks, the optimization of privacy-protecting regulatory policies is a challenge shared by all nations. Due to the immaturity of the personal data market, it is necessary to coordinate the complementary roles of market mechanisms and legal regulatory regimes in the regulation of data privacy and security in order to establish a scientific regulatory framework for the protection of personal information (Tang & Wang, 2020). To overcome the limitations of the unilateral regulatory model, it is necessary to establish a professional data supervision agency led by the government and involving multiple stakeholders, including schools and businesses, in order to ensure the effective usage of data that conforms to legal requirements and public norms.

Enhancing Students' Awareness of Personal Data Protection

Enhancing student self-protection awareness is particularly crucial while the legal framework for personal data protection is still being debated. First, through classroom instruction, case studies, or participation in data management, inform students of the extent of personal data privacy, the dangers of personal data leaking, and the basic, doable steps for protecting personal information. Second, educate students about the uses of data and the difficulties associated with big data and develop their awareness of assessing privacy risks in regular online activities. Tell them to install privacy security shields, exercise caution when authorizing open permissions, and carefully read the "authorization instructions" to determine privacy risks when using social media. Third, assist students in comprehending the fundamentals and features of big data and AI technologies. Also, urge them to keep track of network security issues and actively participate in training and education on the value of personal privacy and the dangers of information leaks.

Providing Students with Legal Remedies against Infringement of Data Privacy

Students have a legal right to privacy protection. There is currently no institutionalized legal protection for student personal data, and schools have not adequately addressed students' rights to privacy (Liu, 2016). Although school-based remedial procedures for student data privacy are currently lacking, the school administration is legally liable for protecting students' educational privacy (Sun, 2007). The school should strengthen its complaints mechanism and strike a fair balance between student privacy and its smart administration. In order to ensure that student-accessible AI applications are held accountable for student data protection, students should also have access to legal remedies from pertinent governmental bodies.

Improving IT Industry Self-Regulatory Mechanisms

The self-regulatory mechanism of the educational technology industry can play a positive role in developing a consensus about user privacy protection and balancing the interests of all stakeholders, whereas overly stringent legal regulations may discourage IT companies from investing in educational AI technology development. A sound IT industry self-regulatory mechanism provides AI practitioners with professional norms and acts as a conduit for supervision from peers, parents of students, education administrators, and other parties in society, which has significant effects on regulating their professional conduct (Chen & Yu, 2018). Compared to the enforcement of legal regimes, industry self-regulation is more practical for preserving student data privacy in the context of constant technological evolution and the exponential growth of AI. AI Industry associations can play a key role in optimizing network identity verification systems, enhancing security evaluation of AI applications, and standardizing ethical impact assessment for emergent AI technologies. Integrating scientific ethics and social responsibilities throughout the entire lifecycle of AI systems, from technological research and development to data collection, analysis, processing, and stewardship, can promote the sustainable, healthy development of AI and increase public confidence in the technology.

Conclusion

The widespread adoption of AI technology in education is necessarily reducing student privacy while gradually increasing the amount of student data. As difficulties relating to student data security become more complicated, educational institutions, governments, and AI actors must work together to create an efficient data protection framework. In a world that is rapidly changing and becoming more electronically connected, students' ability to grow and develop healthily depends on the preservation of their online privacy.

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REVIEW

The Significance of Educational Application of Artificial Intelligence and Its Current State in China

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***Abstract**: The educational application of artificial intelligence (AI) is to integrate AI technology into the educational system including educational components and processes to achieve personalized, inclusive, and more effective education. The adoption of AI technology in Chinese education has considerably improved its efficiency and equity. The purpose of this article is to present the significance of educational application of AI and the status quo of the use of AI technologies in Chinese education.*

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IN the history of artificial intelligence (AI), 2016 is generally viewed as a landmark year, which saw a substantial increase in AI projects (Zhao & Yuan, 2016). In that year, DeepMind's AlphaGo won Go champion Lee Sedol, becoming the first computer Go-playing system to beat a professional Go player. The result of this human-machine match sparked wide attention around the world, giving fresh impetus to the development of AI technology. Driven by the AI strategies of various countries and the influx of capital, the applications of AI technology have tremendously expanded, and education is among the fields that have been most prominently impacted. The 2017 Global (Shanghai) Artificial Intelligence Innovation Summit urged further explorations of AI integration in education. Amid the rapid advances of big data, Internet, cloud computing and other technologies in the past few years, AI has played a vital role in promoting the reform of Chinese education (Zhang & Gu, 2023).

Utilizing technological advantages of AI in educational activities has the great potential to liberate educators from massive, repeated labor and to transform the interaction between teachers, students, resources, and the environment. Currently, the application of AI technology to education has become a major research area, as it affects curriculum planning, teaching methods, and the corresponding reform of overall educational frameworks. A range of relevant concepts have emerged such as "educational application of artificial intelligence," "artificial intelligence education," "educational artificial intelligence," "smart education," "intelligent education," "AI-enabled education" and more. Li (2020) argued that AI applications can serve as an assisting tool in education, with a function comparable to any other educational technology. Zhang & Ji (2018) defined "intelligent education" as a process in which students learn to apply technical tools to intelligent information processing and the construction of intelligent solutions and development systems, thus integrating individual intellectual development with intelligent technology practice. Zhu et al. (2018) pinpointed the three primary components of intelligent education: intelligent technology support, intelligent technology education, and student intellectual development. Wang & Liu (2018) asserted that the "AI educational applications" are the innovative use of AI technologies, models, and practices in the field of education and that they can be divided into three categories: basic-level applications of "computational intelligence+education," enhanced-level applications of "perceptual intelligence+education," and deep applications of "specialized cognitive intelligence+education." Yan et al. (2017) defined educational artificial intelligence as a novel field based on the combination of AI and disciplinary expertise, which focuses on exploring how to actualize and enhance learning by using AI technology and to provide users with conditions for more efficient and effective learning than traditional educational paradigms. In this study, the educational application of AI is defined as the practice of incorporating AI technology into the entire educational system including integrating AI with key educational components (teachers, learners, administrators, educational resources and environments) and educational processes under the frameworks of accepted educational theories and AI ethics in order to provide personalized, inclusive, and more efficacious education.

The Significance of Educational Application of AI

Mutual Promotion between AI Technology and Educational Development

The efforts to apply AI theories to educational activities can be traced back to the 1980s. The program named "Intelligent Tutoring System (ITS)" in 1989 was among the early experiments to combine AI technology with instructional activities (Koedinger et al., 1997). As a result of the incremental advancements in AI, more educational technologies such as learning analytics (Gasevic, 2017) and educational data mining (Zhang et al., 2014), and the International Society of the Learning Science (Long, 2011) arose, bringing profound changes to instructional methods, learning materials, educational evaluation systems, and school management patterns. Technological breakthroughs in AI have been promoting the development of education.

Meanwhile, AI, like any other technology, can only be fully developed through practical applications. It necessitates the employment of enormous volumes of data generated by practical applications to carry out the assessment and improvement of the technology, and education is precisely one of the fields capable of producing massive amounts of data. Therefore, the application of AI in education is beneficial to the progress of AI. In addition, advances in education pose new challenges and requirements on AI technology, which in turn promotes further development of the latter.

Providing an Impetus for the Reform of Chinese Education

Since its reform and opening up, China has been committed to educational equity by implementing the compulsory education, tuition exemption program, and ethnic minority education protection policies to ensure all school-age children the right to education. After entering 21st century, the public put forward new requirements for the national education in addition to the achieved educational universalization, that is, an equal and high-quality education (Hu et al., 2020b). How to popularize high-quality education? AI technology can provide powerful backing to expedite the popularization of high-quality education.

China's educational reform in the ICT era sets the universalization of high-quality education as its primary goal. According to papers issued by the Ministry of Education, all localities have been prompted to experiment educational AI pilot projects; AI educational applications have been spread to underdeveloped areas after being proofed effective by urban schools. Not only schools and other educational institutions are urged to implement educational AI pilot programs, but high-tech enterprises are also encouraged to play pivotal roles in executing the "AI+education" strategy. For example, an AI application developed by Squirrel AI Smart Adaptation Education can detect students' weaknesses in the learning process through machine algorithms, and then offer tailored tutoring accordingly. In addition, policy support and incentives have been inspiring in-service anchor teachers and non-governmental organizations to adopt AI technology to address the unbalanced distribution of educational resources and to ease teacher shortages in impoverished areas.

Status Quo of the Educational Application of AI in China

Educational AI Technologies in Use

The development of AI technology can be divided into three stages: perceptual intelligence, cognitive intelligence, and decision-making intelligence. With technological advances, cognitive intelligence has now become the mainstream research field, which is applied to highly complex scenarios to enable analysis and decision-making through technologies like multi-modal AI and big data. At present, a plurality of AI technologies is being used in a wide range of scenarios such as smart education platforms, virtual laboratories, instructional evaluation and feedback to construct a comprehensive ecosystem which is capable of providing personalized, multi-purpose education (China Electronics Standardization Institute, 2021).

China Electronics Standardization Institute's (2018) "White Paper on Artificial Intelligence Standardization 2018" lists machine learning, natural language processing, knowledge mapping, computer vision, human-machine interaction, biometric recognition, virtual reality, and augmented reality as the seven core AI technologies. All of them are employed in the field of education to varying degrees, with natural language processing, machine learning, and biometric recognition being used more widely. For instance, natural language processing-based translation software provides "online dictionary" for foreign language learners; biometric recognition technology-enabled face and fingerprint recognition can be used to conduct intelligent attendance check in school routine administration; human-machine interaction technology can generate personalized analysis of learning situations of each individual student.

Roles of AI Applications in Education

According to the level of involvement they have in the educational process, AI applications assume different roles, mainly the role as educational actors, the functional role, and assistive role. Their common goal is to maximize technological empowerment through the appropriate integration of AI and education on an on-demand basis, thereby achieving the optimization of educational outcomes (Zhang & Zhang, 2017)

AI Applications as Educational Actors

When AI applications play the roles of educational actors in the educational processes such as teaching, learning, management, and educational decision-making, they are doing the work of teachers, advisors, administrators, or peers. AI applications of this category include the intelligent tutoring system, intelligent Q & A system, intelligent learning through gaming, intelligent school administration, and intelligent decision supporting system. In these applications, AI technology is the pivotal module in the system. They are aimed at liberating teachers, administrators, and decision-makers from copious, repetitive labor so that they can invest more of their time, energy, and expertise in personalized instruction, in the cultivation of student creativity, and in the design of innovative educational programs.

The Functional Role of AI Applications

In some circumstances, AI technology is embedded as supportive modules to perform functions such as learning content recommendation, learning analysis, learning evaluation, learning optimization, and data mining to help teachers, learners, and school administrators improve their performance. Programs such as adaptive learning, personalized learning, and learning through gaming are also run by embedded AI technology.

The Assistive Role of AI Applications

Assistive technology is a framework term, entailing a wide range of applications for assistive, adaptive, and rehabilitative devices for the disabled. Assistive AI technology is not intended to directly impact their academic performance, but rather to compensate for their deficiencies in physical and mental functions and narrow the gap between the disabled and the normal population in basic educational conditions. Assistive technologies such as speech recognition, robotic arms, intelligent prosthetics, intelligent wheelchairs and more can help disabled learners regain normal behavioral functions. For example, FingerReader, a device developed by the MIT Media Lab, can be worn on the finger. With it turned on, the user only needs to move their fingertip along the text on the screen or on the paper, and FingerReader can read the text aloud in real time (Shilkrot et al., 2015).

Major Educational AI Developers and Users in China

Major Internet companies, AI companies, and educational technology companies constitute the majority of educational AI developers, who use their command of internet, AI, and big data technologies to explore how to integrate AI in education. High-tech behemoths such as Baidu and iFLYTEK have made significant achievements in this field. Through its AI applications, iFLYTEK helps Chinese schools to actualize "tailored education." To date, more than 130 million teachers and students from over 50,000 schools have used the iFLYTEK educational AI to improve their teaching and learning outcomes (Yang & Xiao, 2023). A plurality of small- and medium-sized high-tech companies have also invested in the research and development of educational AI. For example, Shanghai Moofen Technology Co., Ltd. has used AI to give precise data analytics to schools in Sichuan, Guizhou, Chongqing, Jiangsu, and other regions (Zhou et al., 2023).

At present, Internet companies such as Alibaba, Tencent, and Baidu are providing popular AI applications such as DingTalk Future Campus, Tencent Smart Campus, and Baidu Smart Classroom. AI companies, such as iFLYTEK and SenseTime offer intelligent hardware products such as translation machines and learning machines as well as AI experiment platforms like SenseStudy and Robot Rover Mini/Pro. Educational technology companies such as New Oriental Education, Squirrel AI Smart Adaptation Education, and Hujiang Education have developed AI education platforms including N-Brain AI Learning Platform, AI Classroom Teachers, K-12 AI Adaptive Tutoring, Uni Intelligent Learning system, Hitalk Oral English Courses, etc.

Education departments, educational institutions, families, and individual learners can all be the users of AI applications, accessing them through purchasing, leasing, and other means. Chinese government has established AI education as a national strategy, which receives positive reactions from the educational communities. Reports on the 2023 Zhejiang Digital Education Conference show that AI will be included as a compulsory subject in primary and secondary curricula in Zhejiang Province and that AI knowledge will be extensively incorporated into science and mathematics.

Information technology is already one of the elective subjects in Zhejiang Province's college entrance examination, and the introduction of AI courses in primary and secondary schools will further prepare students for the AI era (Zhong, 2023). In addition, some schools have created their own intelligent teaching platforms. For example, Shandong 271 Education Group created 271Bay as a digital education platform for its more than 8,000 teachers and 90,000 students (Sun, 2022). In China, digital technology is also employed in student mental health education. For example, a mental health cloud platform in Jiangsu Province has for years committed to student mental health services such as the counseling, diagnosis, and treatment of mental health issues (Quan, 2020).

Conclusion and Prospects

Currently, the application of AI to education exhibits a growing trend. AI technology is a powerful force driving digital education in China. The educational application of AI can significantly contribute to increasing the pool of AI talent while promoting balanced, high-quality education. At the same time, as the use of AI in education increased, many issues emerged, necessitating attention from and debate among all stakeholders. Training AI algorithm models requires extensive use of educational big data, which raises concern over information security issues such as data privacy; the use of AI in the educational assessment spawns the need for relevant regulations; there is the risk of further expanding the digital divide though the application of AI is intended to heighten efficiency and equity in education. Facing AI's rapid advances and its consequential challenges, educational communities must leverage AI technologies to make adjustments in order to meet the demands of social development.

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