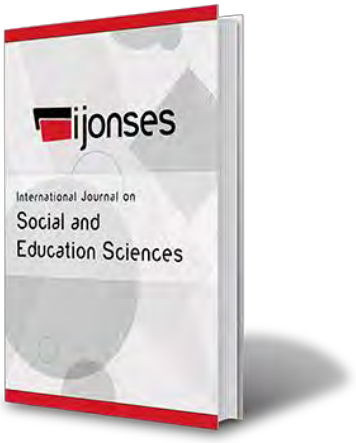

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Liquid-Volume Measurement Estimation Skills of Gifted Students and Suggestions for Saving Water

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Abstract

Water is vital for the survival of living things. It is water that sustains all living organisms, all biological life, and all human activity. Water constitutes 3/4 of the world, 60% of the human body. The need for water is increasing day by day due to the rapid increase in the population and the fact that the water resources remain constant. It is important for individuals to be conscious about water consumption, to be aware of how much they consume. In this context, in this research, students' estimates of the amount of water they consume, liquid-volume measurement estimates and their views on water conservation were examined. This study aims to examine the liquid-volume measurement estimation skills of gifted students and to examine their views on water conservation. This study was conducted as per the case study design, which is one of the qualitative research designs. The study group of the study consisted of 24 gifted students studying in the 6th grade in a Science and Art Center in a province located in the southern region of Turkey in the 2022-2023 academic year. As a result of the research, it was observed that the students had moderate liquid-volume estimation skills and the male students had more liquid-volume estimation skills than the female students. In addition, it was concluded that students had a low average score in liquid-volume estimation problems involving real-life situations, and that the most opinions about water conservation were in the theme of limitation and penalty application.

Introduction

Among the important causes of environmental problems is the unconscious consumption of natural resources. The use of existing resources as if they will never be exhausted and not being aware of this will eventually turn into a big problem that cannot be prevented in the future. There is no doubt that water is indispensable for people's lives in natural resources (Tuna& Anılan, 2021). Water, which is an indispensable element for the continuation of life, is a natural and scarce resource that cannot be replaced. Water resources are important not only for human beings but also for all living things and the continuation of the habitable environment on Earth. To use water consciously as a whole society and to make it sustainable, every individual should be aware of water (Yazıcı & Koçer, 2020).

Earth is named the blue planet because of the abundance of water that exists. However, 97.5% of the available water exits as salt water in the oceans and seas, and 2.5% of it exits as fresh water in rivers, lakes, underground

and glaciers (Ursavaş & Aytar, 2018). Since 30.1% of freshwater is groundwater and the remaining 0.4% is surface and atmospheric waters, the rate of water that can be easily reached and used is only 0.4% of the total body of water (Kılıç, 2017). As a result, water resources are quite limited and it is the responsibility of each individual to use them carefully. Recently, countries have begun to look for various solutions on how to consume water resources consciously. The level of consciousness to be increased in this way will be beneficial both for the benefits of the countries themselves and for the future of the world at the global level (Gündüz & Bilir, 2012).

The fact that individuals do not have awareness of how much water they consume may be one of the reasons for excess water consumption. In their research, Tuna and Anılan (2021) showed the documentary, *25 Liters*, to the students to examine their water awareness. As a result of the research, the students stated that they did not think that a person's daily water consumption could be so much, that the thirst problem was a bigger problem than considered, that the 25 L water documentary was effective in realizing the effects and importance of the thirst problem to be experienced in the future and to take steps to take the necessary measures.

The fact that the students did not think that a person's daily water consumption could be too much brought to mind their estimation skills for the amount of water consumed. Estimating is an action that takes place both in daily life and in scientific research and is not coincidental (Bulut, 2019), makes life easier and saves time (Aydoğdu, 2020). Estimation requires approximate calculation (Er, 2023; Tiryaki, 2022). In the field literature, estimation is defined as reaching the real answer in the shortest way (Reys, 1986), reaching the result in the fastest way without counting and measuring precisely (Micklo, 1999), and a process that is done without paper and pen and does not result definitively (Aslan, 2011).

Measurement is the comparison of a certain property of an object or situation with a quantity that is accepted as a unit of similar property (Baykul, 2009). Estimation in measurement is the estimation ability of height, length, weight, volume, liquid capacity and similar measurements of objects generally used by everyone (Satan, 2020). In mathematics, just as estimation and calculation have a connection with the feeling of numbers, making measurements has a connection with the feeling of measurement. The feeling of measuring is not instantaneous, but a skill that covers a process and allows us to understand measurements and units more easily (Aydoğdu, 2020). Gaining the sense of measurement to individuals starting from the early period and having real-life situations measured in the lessons will positively affect the measurement performance of the students (Tiryaki, 2022).

In the curriculum of recent years, the ability to process from the mind, the ability to predict the result by reasoning and the development of easy processing skills are included. In the curriculum published in Turkey in 2018, in addition to being included in the special objectives of the mathematics course and within the explanations related to the learning areas, the following statement is also included: "Will be able to use the skills of estimating and processing from the mind effectively." (MONE, 2018).

During education, not every individual is the same, and there are individual differences. One of the groups of students who differ individually is the students with superior abilities. Gifted individuals constitute the student group who will form the intellectual segment in the society if their potential is evaluated correctly by giving

appropriate trainings to them (Bakar, Avan &Aydınlı, 2018). In this respect, gifted individuals will contribute positively to the development of both their immediate environment and society (Sontay, Gökdere & Usta 2014). It has been observed in the field literature that the number of studies on this subject has increased with the increase in environmental problems and negative effects on life. In the field literature, there are studies available in which the environmental knowledge of gifted students and their positive attitudes towards the environment are examined (Aydın & Kaya, 2011; Bakar, Avan & Aydınlı, 2018; Ceylan, 2022; Esen, 2011), and in which students' water footprint, water awareness and water literacy are discussed (Özerdinç & Hamalosmanoğlu, 2021; Ursavaş & Aytar, 2018).

Researchers have suggested that more groups of students and students at different grade levels need to uncover their knowledge and awareness of water (Ilgar, 2020).In addition, in studies conducted to date on measurement estimation, there are studies in which students' measurement estimation performances and the estimation strategies they use are determined (Albarracín, Ferrando & Gorgorió, 2021; Corle, 1960; Er & Artut, 2021; Gooya, Khosroshahi & Teppo 2011; Kılıç & Olkun, 2013; Sowder, 1992; Russo, MacDonald & Russo, 2022) In addition, studies are also found in which the development of dimensional estimation skills (Swan and Jones, 1980), the performance of students in operational, metric estimation and batch estimation skills, the strategies they use are discussed together (Tekinkır, 2008), and in which the relationship of dimensional estimation skill with different variables is discussed (Altunkaya, Aytekin, Özçakır & Doruk, 2014; Çetin & Köse, 2015).

Within the available resources, there was no study in which the liquid-volume measurement estimation skills of gifted students and their suggestions for water conservation were discussed. Determining the liquid-volume estimation skills of gifted students and determining their suggestions for water conservation are important in terms of revealing their awareness of these issues. In this context, the following research questions were formed in this research.

- What are the students' liquid-volume measurement estimation skills?
- What are the students' suggestions for saving water?

Method

In this part of the research, information about the model of the research, study group, data collection tool and data analysis is included.

Research Model

In this research, qualitative research method was used. Qualitative research is a form of research in which qualitative data collection methods such as interview, observation, and document analysis are used and a qualitative process is followed to reveal events in a realistic and holistic way in the natural environment (Yıldırım & Şimşek, 2008). In this research, which aims to examine the liquid-volume measurement estimation skills of gifted students and to examine their views on water conservation, the data was obtained by using document analysis and interview technique.

Study Group

The research was carried out with 24 (11 girls, 13 boys) students attending Science and Art Centers (SAC) from 6th grade secondary school students in a province located in the southern region of Turkey. The study group was determined according to the appropriate sampling method from non-probability based sampling methods. The purpose of choosing the appropriate sampling method is that the researcher is close to the participants and easy to access (Patton, 2014). In addition, another reason why the study group was chosen as this student group is that gifted students are more sensitive to the environment than students without gifted diagnosis and have the potential to offer creative solutions to water conservation. The fact that students attend science and art centers (SAC) means that they are diagnosed as gifted. The gifted student group is limited to students who are nominated by their teachers with the observation forms sent to the schools by the Ministry of Education and who continue to SACs by successfully completing the diagnostic processes. These are students who study at SAC in addition to their formal education, whose IQ score is determined to be 130 and above by a standardized test conducted by the Ministry of National Education at the end of 1st, 2nd and 3rd grade.

Data Collection Tool and Analysis of Data

The data were obtained using the document analysis and interview technique. As a document, 24 answer sheets containing the answers of students to eight questions were used. The data collection tool was created by the researcher and applied to each student. Liquid-Volume Measurement Estimation Problem Worksheet (LV-MEPW), which includes demographic information and eight problems, was used as data collection tool. While creating the data collection tool and evaluation rubric, opinions of a mathematics education expert and a language expert were taken, corrections were made, then the final version was achieved.

The question “How many liters of water does a barrel take?” in the data collection tool was removed from the data collection tool considering that the barrel sizes were not standard and that the students may not have encountered the barrel before, and the data collection tool took its final eight-item form. During the implementation process, participant students were told that they were expected to make the first problem solutions that came to their minds and that they had 50 minutes. The 2nd and 6th problems in the data collection tool include the liquid-volume measurement relationship and information, and the other problems include the liquid measurement information. The type of each problem, the point value and the evaluation rubric are given in Table 1. Regarding the evaluation of forecasting ability in the field literature, Van de Walle has expressed that estimates in the range of 10% in length and even 30% in volume and weight are acceptable for acceptable estimation. Baroody and Gatzke (1991) stated that values between 25% less and more than 25% of the actual answer would be acceptable, and some researchers used the 50% range in their studies (Barody and Gatzke, 1991; Crites, 1992; Siegel, Goldsmith and Madson, 1982). In this study, while evaluating the estimation skill in the 2nd and 3rd problem types, +-50% of the actual or possible answer was accepted as the acceptable predictive value and scored as in Table 1. To ensure reliability in scoring, a mathematics educator other than the researcher also scored. The Pearson correlation coefficient for the total score for the calculation of reliability between raters was calculated as 0.94.

Table 1. Problem Type, Point Value and Assessment Rubric

Problem type	Point value	Problem	Evaluation Rubric
1. Type of problem requiring knowledge	1	P1: How many milliliters is 1 liter?	Answer: 1000mL Rated as correct answer: 1, Incorrect answer: 0.
	1	P2: How many liters of water is $1m^3$? **(Contains liquid-volume relationship)**	Answer: 1000 L Rated as correct answer: 1, Incorrect answer: 0.
2. Type of problem with exact answer that requires estimation	2	P3: Estimate the maximum amount of water taken by the objects in the image below and write them in units.  Tablespoon:……..	The definitive answer: 10mL If 5mL< Given answer < 15 mL, 2 points were given; if not, 0 point was given.
	2	P4:  Water glass:…….	The definitive answer: 200mL If 100mL< Given answer < 300mL, 2 points were given; if not, 0 point was given.
	2	P5: How many bottles of water can I fill from a 2 lt jug with a standard tea cup (a thin-waisted tea cup)?	The definitive answer: 2000mL/100mL = 20 cups. If 10 glasses < Given answer < 30 glasses, 2 points were given; if not, 0 point was given.
	2	P6: If our classroom was a pool, how much water would we need to fill it all with water? **(Contains liquid-volume relationship)**	The definitive answer: 150000 L If 75000L< Given answer < 225000mL, 2 points were given; if not, 0 point was given.
3. Type of problem without exact answer that requires a set of estimations (Fermi problem)	3	P7: Estimate approximately the amount of water a person drinks during his or her lifetime.	Possible answer: 75000L If 32500L< Given answer < 107500mL, 3 points were given; if not, 0 point was given.
	3	P8: Estimate the average monthly amount of water consumed (kitchen, toilet, bathroom) in a family of 4 people.	Possible answer: 20000L If 10000L< Given answer < 30000mL, 3 points were given; if not, 0 point was given.

In this research, to determine the students' views on water conservation, "The importance of water in the world is increasing and the need for water is increasing. Imagine yourself as an expert who would solve this problem, and what would be your suggestions for solving this problem?" The interviews were recorded as audio recordings and transcribed. The data obtained was analysed with the content analysis method. Content analysis is the thematic analysis of data in terms of certain categories by scanning it in a systematic way. With the data obtained in content analysis, there is identification, counting and interpretation of recurring topics, problems and concepts (Denzin & Lincoln, 1998). In order not to disclose the identities of the students, codes in the form of S1, S2 were given.

Findings

In this section, the results of the analysis made in line with the research findings are included.

Findings on Students' Liquid-Volume Measurement Estimation Skills

The answers given by the students in the Liquid-Volume Measurement Estimation Problem Paper, which includes demographic information and eight problems, were examined and scored. The mean scores and standard deviation values obtained from the analysis result are presented in Table 2.

Table 2. Liquid-Volume Measurement Estimation Skill Score Averages and Standard Deviation Values

	N	$\bar{X}$	**SD**
Female	11	7.36	3.324
Male	13	8.76	2.618
Total	24	8.12	2.982

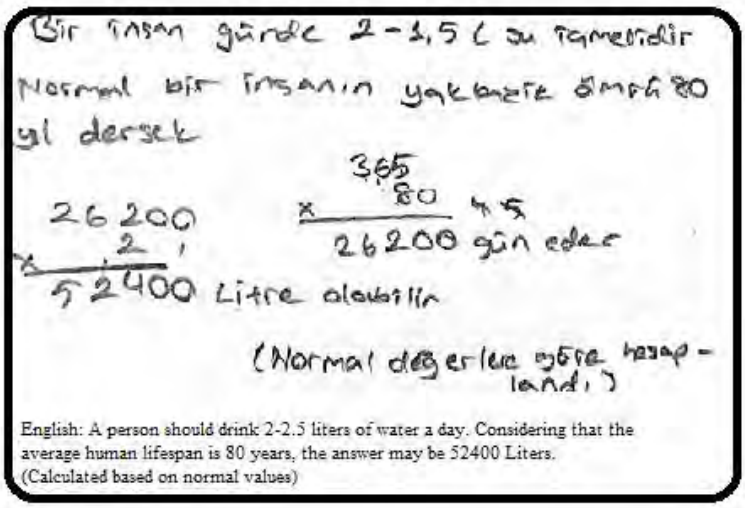
According to Table 2, it is seen that the mean score of male students ($\bar{X}$=8.76) from the answers they gave to the data collection tool was lower than the average score of female students ($\bar{X}$=7.36). Hence, it can be said that the average score of male students is higher than female students. Considering the average total score ($\bar{X}$=8.12) and the maximum score that can be obtained from the data collection tool (16), it can be said that the students have intermediate liquid-volume estimation skills.

The students' correct answers according to the type of problems and the average point value of each problem are presented in Table 3. The maximum score that can be obtained from the two problems of the first problem type is 2, the maximum score that can be taken from the 4 problems of the 2nd problem type is 8, and the maximum score that can be taken from the 2 problems of the 3rd problem type is 6. According to Table 3, it can be said that the average of the total score obtained from the answers given to the 1st problem type ($\bar{X}$=1.70) is high considering the maximum score (2) that can be taken. Considering the average of the total score obtained from the answers given to the second problem type ($\bar{X}$=4.66) and the maximum score (8) that can be taken, it can be said that the average of the total score obtained from the answers given to the 3rd problem type ($\bar{X}$=1.75) is low considering the maximum score (6) that can be taken.

Table 3. Analysis Findings by Problem Type

Problem type	Problem no	Frequency of correct answers (%)	$\bar{X}$
1. Type of problem requiring knowledge	P1	23 (%95.83)	.95
	P2	18 (%75)	.75
	Total		**1.70**
2. Type of problem with exact answer that requires estimation	P3	13 (%54.16)	1.08
	P4	17 (%70.83)	1.41
	P5	19 (%79.16)	1.58
	P6	7 (%29.16)	.58
	Total		**4.66**
3. Type of problem without exact answer that requires a set of estimations (Fermi problem)	P7	12 (%50)	1.50
	P8	2 (%8.33)	.25
	Total		**1.75**

Hence, it can be said that students have sufficient knowledge about liquid-volume measurement requiring knowledge, and that they have less knowledge in the problem requiring liquid-volume relationship (P2) than in the problem requiring liquid measurement knowledge (P1). Similarly, in the type of problem with a definite answer that requires estimation, it is seen that the mean of the least score ($\bar{X}$=0.58) in the estimation problem involving the liquid-volume relationship. Examples of some of the students' solutions are presented in Figure 1 and Figure 2.



English: A person should drink 2-2.5 liters of water a day. Considering that the average human lifespan is 80 years, the answer may be 52400 Liters. (Calculated based on normal values)

Figure 1. S13's Response to P7

In Figure 1, S13 answered within the acceptable range of estimations and received a score of 3 from P7's solution. Figure 2 shows S4's answer to the estimation problem that requires knowledge of the liquid-volume relationship, namely P6. S6 tried to calculate the dimensions of the class in terms of units of volume measurement and found the volume of the class to be 32 m^3. The student estimated the volume of the class much smaller than its actual value and did not specify the amount of water in liters that the class would take, since the liquid-volume

information was not sufficient. The student did not get points from the solution of this problem.

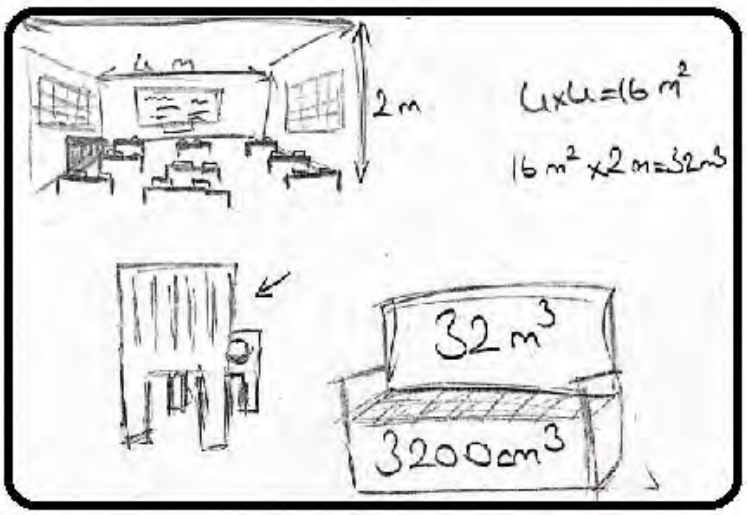


Figure 2. S4's Response to P6

Opinions of the Students for Suggestions to Save Water

The students were asked the question "The importance of water in the world is increasing, and the need for water is increasing. Imagine yourself as an expert who would solve this problem, and what would be your suggestions for solving this problem?" so that his suggestions on water conservation are collected in the themes in Table 4. According to Table 4, the data obtained from the analysis of the students' responses were collected under 4 themes: ensuring recycling, preserving existing resources and finding new resources, limiting and punishing, and raising-improving awareness. On the theme of ensuring recycling, the students expressed views such as To convert salt water into fresh water (f: 7), To establish a rainwater collection station (f: 4), To recycle waste water (f: 3), To establishing water collection stations in houses (f: 2). On the theme of preserving existing resources and finding new resources, students expressed views such as To produce artificial water (f: 2), To produce cleaning products that do not require water (f: 1), To cover water sources (rivers, water channels) with glass to prevent evaporation (f: 1), To ensure that rivers discharge into dams (f: 1), To bring water from space (from other planets) (f: 1). The students expressed opinions on the theme of limitation and penalty application as follows: To introduce a daily water usage limit (f: 9), To apply a penalty for exceeding the usage limit (f: 9), To use self-closing taps (f: 3), To close the pools (f: 1). The students provided following opinions on the theme of raising and improving awareness as follows: To make an effort to become conscious (f:2), To create awareness (f:1), To have advertisements about the importance of water (f:1). Some opinions of students on this method are given below.

> Rainwater collection stations can be established. Recycling wastewater can be provided. Water can be brought efficiently from space. By covering rivers and water channels with glass, water vapor is reduced, and this lowers the air temperature. Rivers can flow into dams, not into the sea. Of necessity, everyone should have a water collection area in their home, and this can be a treatment system (S1).
>
> We can use the water we use during bathing when we use flushing. A certain amount of water can be provided to the houses every day. We can purify polluted water. For the siphon we can use salt water. If it is possible, we can turn milk into water (S3).

Rainwater should be sucked from the roofs and come to a reservoir, then with the water accumulated here can be washed the car or watered the plants. Water with which we wash our hands can be used in siphon. We can pass the rainwater through a filter and make drinking water (S14).

People should use water more consciously and water should be given limited (S18).

There may be restrictions on using a maximum of 50 liters of water every day, advertisements showing the importance of continuous water conservation and penalties for those who waste water (S17).

Table 4. Opinions on Suggestions for Water Conservation

Themes	Sub-Themes	Student Code	*f*
Ensuring recycling	To set up a rainwater collection station	S1,S9,S20, S21	4
	To recycle wastewater	S1,S3, S5	3
	Installation of water collection stations in homes	S1,S14	2
	To turn milk into water	S3	1
	Use of sea water for drains such as siphon etc.	S3	1
	The use of household wastewater for siphon	S14,S20	2
	To convert salt water into fresh water	S7,S8,S9,S10,S21,S23,S24	7
Preserve existing resources and find new resources	To bring water from space (from other planets)	S1	1
	To cover water sources (rivers, water channels) with glass to prevent evaporation	S1	1
	To allow rivers to drain into dams	S1	1
	To produce artificial water	S15,S16	2
	To produce cleaning products that do not require water	S11	1
Restriction and imposition of penalties	To use self-closing taps	S2,S10, S12	3
	To set a daily water usage limit	S2, S3, S4, S7, S11, S17, S18, S20, S22	9
	To close pools	S7	1
	To impose a penalty for exceeding the usage limit	S4,S7,S9,S10,S11,S12,S15,S17,S23	9
Ensure and improve awareness	To make an effort to become conscious	S18, S20	2
	To advertise about the importance of water	S17	1
	To raise awareness	S20	1

From Table 4, it can be seen that the majority of the students presented suggestions in the sub-themes of Introducing a Daily Water Use Limit (f: 9) and Imposing a Penalty for Exceeding the Usage Limit (f: 9) in the theme of limitation and penalty application.

Discussion and Conclusion

This research, which examined the liquid-volume measurement estimation skills of gifted students and their views on water conservation, is based on data obtained from 24 students. In this research, it was observed that the students had moderate liquid-volume estimation skills and the male students had more liquid-volume estimation skills than the female students. Çetin and Köse (2015), in their study aiming to examine the relationship between the operational and measurable estimation skills of 8th grade primary school students and their mathematical literacy, and as a result of the research, it was concluded that there was no significant difference between the dimensional estimation performances of the students according to gender and that the estimation skills of female students were higher than those of male students.

Er (2023) stated that in the research aimed to determine the dimensional estimation performance of seventh grade secondary school students and the dimensional estimation strategies they use, the dimensional estimation skills of male students were better than the dimensional estimation skills of female students. Just as there are studies in which predictive ability differs significantly by gender in the literature (Dowker, Flood, Griffiths, Harriss, & Hook, 1996), there are also studies where there is no statistically significant difference (Forrester and Pike, 1998; Satan and Yetkin, 2022; Tekinkır, 2008). From here, it can be said that this research finding is similar to the field literature. In addition, in this study, it was seen that the fluid-volume death prediction skills of the students were at a medium level. Although it is stated in the field literature that improving estimation skills is important both in daily life and in scientific studies, it can be seen that the dimensional estimation skills of individuals are low in studies conducted so far.

This result can be said to be partially in parallel with findings of studies conducted in the field literature (Corle, 1960; Clayton, 1988; Er & Artut, 2021; Kumandaş & Gündüz, 2014). Bulut (2017) examined the views of mathematics teachers in secondary school about the concept of estimation. As a result of the research, it was seen that teachers could not define estimation and did not have enough information about the types and strategies of estimation. In the findings obtained in this study, the fact that the level of dimensional estimation skills of gifted students is at a medium level can be related to the perspective of teachers on this issue, which is an important factor in the development of estimation skills.

In this research, the problems that the students were most successful according to the problem type were the types of problem requiring information, the estimation problems with definite answers and the estimation problems without definite answers. The fact that the students were least successful in the 7th and 8th problems, which included the real-life situation, shows that their estimates of the amount of water they use in daily life are not at the desired level given the contents of the problems. Tuna and Anılan (2021) stated that considering the technological developments and the rapid increase in the population in the age we live in, natural resources may be insufficient to meet the needs of people, and if measures are not taken, in the near future we will face many problems such as various epidemic diseases, the spread of negative moral behaviors in society, the psychological impact of people on this situation. In their study, the researchers had the students watch the documentary 25 Liters of Water and examined their awareness of water consumption. As a result of the research, the students expressed

the opinion that they thought that the amount of water they consumed daily was less. In this research, as in the field literature, it is similar that students cannot predict in the 7th and 8th problems involving real-life situations.

The fact that students are more successful in questions that require knowledge may be due to the fact that they encounter problems that require one correct answer in the educational process and exams. According to Table 4, the data obtained from the analysis of the students' responses to saving water were collected under 4 themes: to ensure recycling, to preserve existing resources and to find new resources, o limit and punish, and to raise-improve awareness. In addition, it has been observed that the majority of the students presented suggestions of Introducing a Daily Water Use Limit (f: 9) and Imposing a Penalty for Exceeding the Usage Limit (f: 9) in the theme of limitation and penalty application. Ursavaş and Aytar (2018) indicate that even a small step taken to prevent conscious consumption, economical use and water pollution is important to ensure that the water, which we have easy access to now, is sufficient for future generations. The way to achieve these goals is possible with individuals who have problem-solving skills, who can develop alternative solutions to a problem, who are aware of the benefits of sustainable development and most importantly, who are responsible. In this context, it can be deemed important to listen to the suggestions of students who have been diagnosed with gifted ability in water conservation and to allow them to implement their suggestions.

Suggestions

Since the students' dimensional estimation skills are not at the desired level, it is recommended to increase the number of activities and achievements for this skill in the mathematics curriculum. Qualitative research methods were adopted in this research; this research can be repeated with larger sample, different grade levels and more items. In addition, conducting studies that are compared with the data obtained from gifted students and non-gifted students may increase the generalizability of this research and contribute to the field literature. In addition, corelational studies can be carried out to examine the relationship between different data collection tools and liquid-forecasting measurement skills and skills such as water literacy.

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