Journal of Turkish Science Education, 2023, *20*(3), 418-432.
DOI no: 10.36681/tused.2023.024

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Development of Online science process skills test for 8th grade pupils

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ABSTRACT
Science process skills are an important part of scientific inquiry that need to be monitored so that pupils can improve their skills to do science. Although there are several science process skills tests mentioned in the literature, we decided to develop an online one in order to improve the usefulness of the test and enable autoscoring to reduce the efforts needed from the teacher. For this purpose, a 17-item test with 2 open-ended and 15 multiple-choice items was developed. After the pilot with 18 8th grade pupils, the study was conducted with 83 8th grade pupils from Bursa in Turkey. Content validity was ensured since all 14 science process skills in the selected theoretical framework were covered in the test. Item analysis showed that these items are valid and reliable as KR20 showed a 0.75 reliability rating, item difficulties were higher than 0.40 and discrimination indexes were higher than 0.30. To gain a deeper insight, distractor analysis showed that all distractors were found to be functional. The test provides a more comprehensive and efficient method of assessing pupils' science process skills, while also enhancing pupil engagement and accessibility. It has the potential to inform instruction and support for pupils, as well as advance research in the field of science education.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received:
12.05.2023
Accepted:
27.09.2023

KEYWORDS:
Assessment of science process skills, science process skills, middle school students, test development.

To cite this article: Sarıoğlu, S. (2023). Development of online science process skills test for 8th grade pupils. *Journal of Turkish Science Education,* 20(3), 418-432.

Introduction

The science process skills are a set of skills that enables pupils to learn science more easily (Social Environmental and Scientific Education [SESE], 1999). These skills increase the sense of responsibility and confidence in self-acquisition of knowledge, increase the permanence of knowledge and enable pupils to acquire effective research methods (Çepni et al., 1997, p. 31). These skills are the skills that scientists apply and frequently use while conducting scientific research (Rezba et al., 1995; Tan & Temiz, 2003). In order to define these skills, based on the objectives of the National Science Teachers Association's science curriculum development report (Carleton, 1964), many different classifications have been made until today. Table 1 shows some important classifications of these skills.

Table 1

Classification of Science Process Skills

(Padilla, 1990)	(Gabel, 1993)	(Rezba et al., 1995)	(Smith, 1995)	(Çepni et al., 1997)	(SESE, 1999)	(Chiappetta et al., 2015)
Basic Skills Observing Inferring Measuring Communicating Classifying Predicting *Integrated Skills* Controlling variables Defining operationally Formulating hypotheses Interpreting data Experimenting Formulating models	Observation Classification Measurement Making inferences and predictions Controlling variables and hypothesis testing Defining operationally Hypothesising and experimenting Using large and small numbers Proportioning and graphing Problem solving Using models and theories	*Basic Skills* Observing Inferring Measuring Communicating Classifying Predicting *Integrated Skills* Identifying variables Constructing a data table Constructing a graph Defining variables operationally Acquiring and processing data Analysing investigations Designing investigations Hypothesising Experimenting	Observing Classifying Inferring Predicting Measuring Communicating Using space/time relations Defining operationally Formulating hypotheses Experimenting Recognizing variables Interpreting data Formulating models	*Basic Processes* Observing Measuring Classifying Recording data Establishing number space relations *Causal Processes* Predicting Identifying variables Interpreting data Inferring *Experimental Processes* Hypothesising Using data to formulate models Experimenting Identifying and controlling variables Decision making	*Scientific Study* Asking questions Observing Predicting Investigating and experimenting Estimating and measuring *Analysing* Sorting and classifying Recognising patterns Interpreting Recording and communicating Evaluating *Designing and Making* Exploring Planning	*Basic Skills* Observing Inferring Space and time relations Classifying Measuring Predicting *Integrated Skills* Defining a term operationally Formulating models Controlling variables Interpreting data Hypothesising Experimenting

In order to effectively involve themselves in scientific inquiry and problem-solving, pupils must acquire science process skills (Brotherton & Preece, 1996; Rezba et al., 1995; Ülger & Çepni, 2021). Utilising their range of cognitive and manipulative abilities through science process skills is the key to comprehending and implementing scientific concepts and procedures through science process skills (Chokchai & Pimdee, 2019; Hernawati et al., 2018; Kavak & Deretarla Gül, 2021; Preece & Brotherton, 1997). These proficiencies serve as the foundation for becoming scientifically literate individuals while also preparing them for careers within STEM (Science, Technology, Engineering and Mathematics) fields. As seen in Table 1, researchers have approached the issue from different perspectives and classified science process skills in different ways. The ongoing evolution of science hand in hand with technology also creates the need for updating Science process skills. When science process skills are considered as the ways and methods followed by scientists, the skills required by scientists have accordingly changed over historical time. Wellington (1989, p. 49) argues that many of the skills accepted as science process skills have a very weak relationship with science, can be acquired without any training and that there is no evidence for the development of these skills independent of context. The evaluation of science process skills as separate (Gabel, 1993) or integrated (Çepni et al., 1997; Chiappetta et al., 2015; Rezba et al., 1995) processes or according to the way scientists use them (Ostlund, 1992, 1998; Padilla, 1990; Wellington, 1989) has brought about diversity in this classification which makes measuring science process skills far from straightforward.

Measuring Science Process Skills

Measuring a pupil's grasp of these skills allows teachers to identify areas where specialised instruction or support may be required; it can offer insightful feedback that will provide pupils with direction pertaining to recognising their strengths along with their weaknesses thereby directing targeted efforts at getting better overall proficiency levels associated with science process skills. When the literature is examined, many researchers have utilised only multiple-choice questions to measure science process skills (Aydoğdu, 2017; Aydoğdu et al., 2012; Bahşi̇ & Açıkgül Fırat, 2020; Ergül et al., 2011; Fathonah et al., 2018; Gill, 2019; Özçelik, 2019; Özgelen, 2012; Şensoy & Yıldırım, 2017; Şıvgın, 2019; Smith, 1995; Uysal & Cebesoy, 2020). However, there are also studies that utilised open-ended questions and activities, considering that the data collected only with multiple-choice questions would not be sufficient due to the nature of science process skills (Azizah et al., 2018; Çepni, 2004; Indri et al., 2020; Rezba et al., 1995; Rillero, 1998; Şahin et al., 2018; Serevina et al., 2018; Strong, 2013; Wu, 1994). All these latter studies were conducted with a limited number of participants due to the fact that they were conducted face-to-face and manually with the participants (Leat & Nichols, 2000). Such approaches cannot provide sufficient data to comment on the change in pupils' science process skills over time (Bearman et al., 2020; Bybee, 2006; Harlen, 1999; Lederman & Stefanich, 2007; Paine, 2020; Richardson & Clesham, 2021; Secolsky & Denison, 2012).

To address these issues, an online science process skills test was developed. This test is unique in that it is web-based and supported by videos that provide a more engaging and interactive experience for pupils. In this study, the classification of science process skills developed by Çepni et al. (1997), as emphasised in the Turkish science curriculum, was used. The test is intended to provide science educators with more accurate and efficient results when assessing pupils' science process skills. This article discusses the rationale for the development of the online science process skills test, the methodology used in its development, and its potential impact on science education.

Rationale for the Development of the Online Science Process Skills Test

When the related literature is analysed, it is seen that the basic science process skills that pupils are expected to acquire at the primary school level are low (Aydoğdu et al., 2012; Fathonah et al., 2018; Keskinkılıç Yumuşak, 2017; Özçelik, 2019; Özgelen, 2012). Studies involving science process skills associated with cognitive processes (Çepni & Kara, 2019; Özgelen, 2012; Uysal & Cebesoy, 2020) with various learning approaches (Lederman & Stefanich, 2007; Şensoy & Yıldırım, 2017; Türkmen & Kandemir, 2011) are frequently encountered. Traditional methods of assessing science process skills (Observing, Measuring, Classifying, Recording data, Establishing number space relations, Predicting, Identifying variables, Interpreting data, Inferring, Hypothesising, Using data to formulate models, Experimenting, Identifying and controlling variables and Decision making) is a high-cost affair in terms of time and workload for the teacher, especially in crowded classes. Paper and pencil tests focus on testing memorisation of science concepts rather than recognising and practising process skills. Interviews and observations require a large investment of time, resources and expertise from science educators.

In contrast, an online science process skills test offers several advantages. It is thought to be an interactive tool that allows pupils to practise science process skills in a more engaging and meaningful way as it allows them to engage with an experiment via videos. Pupils are thus engaged in a thought experiment which may increase their level of comprehension of the scientific process happening. It also has the ability to provide science educators with more accurate and efficient results for assessing pupils' science process skills as it is convenient and can auto-score via applications such as Google Forms.

Methodology

Research Design

The study was conducted along the lines of an exploratory sequential design of mixed methods (Creswell & Plano Clark, 2013). Qualitative data were collected about the instrument developed and after that quantitative data were collected for the same purpose to strengthen the results. Within the scope of the study, the 60-question science process skills questions prepared by the author for the purpose of measuring science process skills were presented to a panel of experts, as a result of which the use of multiple-choice questions was abandoned because it was thought that they could only measure the skills at the knowledge level. Scenarios were prepared for the 14 science process skills (Çepni et al., 1997; MoNE, 2018), and an "open-ended science process skills test", consisting of 14 open-ended questions was prepared by the researcher for these scenarios and submitted for expert opinion (3 field expert academicians, 3 question writer science teachers). It was thought that the thought experiment would be above the cognitive level of the pupils, and its use was abandoned. Thereupon, the multiple-choice and open-ended test attempts were abandoned according to the expert opinions and a new test preparation process started. The online Science process skills test, which was prepared with two video experiments publicly accessible on the YouTube platform and consisted of 2 open-ended and 15 multiple-choice questions in a total of 17 questions, was prepared. The open-ended 2 questions on measuring and using space-number relations were scored 1 for correct answers and 0 for others. Multiple choice questions were of 4 options, 1 of them was correct and 3 were distractors. The test then was presented to the expert opinion of 6 field expert academicians and 4 science teachers. The prepared test items were submitted to the expert opinions of 7 science education experts (5 professors, 1 associate professor and 1 doctoral faculty member) and 3 science teachers (9, 11 and 17 years of professional experience, trained in question writing and measurement and evaluation). In line with the expert opinions, necessary corrections were made in the statements and the way the questions were asked. As examples of these corrections, suggestions for corrections such as "The second and third options falsify each other, it would not be appropriate if the student makes inferences from the options rather than from observation." and "It would be more appropriate to change the second sentence in the question stem as 'How many seconds does it take for the first empty bottle to empty from the moment it is turned upside down?" were collected through google forms and all the corrections decided to be necessary were made.

Pilot Study

The test, which was assumed to be ready for use after the corrections made in the statements and the way the questions were asked in line with the expert opinions, was first presented to 18 pupils (10 male and 8 female) chosen randomly from a convenient nearby middle school before the pilot application and their feedbacks about the clarity of the items were asked. There was no negative feedback from the pupils thus usability was ensured.

Sample

After the test was deemed ready for use, responses from 145 randomly selected 8th-grade pupils, from 3 different public and 1 private school in Bursa, Türkiye, were collected. Considering the 14 science process skills, the sample size is recommended to be at least 5 times the number of questions (Büyüköztürk et al., 2008), which is met in the study. When estimating the population of 8th-grade students (at the age of 14 or 15) studying in Bursa to be 40,000, a sample size of 145 students represents the population with an 8% margin of error at a 95% confidence level. Seventy-six of the respondents were male and 69 were female. The data were collected via Google Forms and answers were analyzed on Google Sheets. Before the analysis, the data were checked and 62 responses were cleared for reasons such as respondents not completing the test, or patterns detected in answering questions, for example when all the answers given by a pupil were the same. In conclusion, data from 83 pupils were analyzed, 38 of which were female and 45 male.

Data Analysis

The first data were collected from experts via Google Forms as qualitative data about their opinions on items and the test. Each expert's opinion was analysed individually to ensure there is no necessary step left to take for improvement. After expert opinions, the validity and reliability of the test were checked with the quantitative data from pupils. The collected data were analysed via descriptive statistics, item analysis and distractor analysis. In this process, SPSS 26.0 package software, Microsoft Excel, and TAP item analysis software were used. Data were entered exported from Google Forms to Excel and then transferred to SPSS and TAP as a .csv file for statistical analyses.

Results

Reliability and Validity

In order to comment on the reliability of the test, the KR-20 value was examined with the help of the SPSS package software and it was found that the reliability coefficient of the test was 0.752, therefore it was concluded that the test could make sufficiently consistent measurements (Hasançebi et al., 2020). Difficulty and discrimination indices of the items in the test are given in the Table 2 below.

Table 2

Difficulty and Discrimination Values of the Items in the Online Science Process Skills Test and the Skills Items Target

Item	Difficulty	Discrimination	Science Process Skill
1	0.83	0.34	Observing
2	0.73	0.53	Measuring
3	0.72	0.56	Recording data
4	0.84	0.31	Inferring
5	0.70	0.47	Predicting
6	0.83	0.34	Identifying variables
7	0.80	0.41	Identifying variables
8	0.69	0.63	Identifying variables
9	0.80	0.34	Hypothesising
10	0.75	0.44	Establishing space number relations
11	0.84	0.31	Interpreting data
12	0.64	0.72	Decision making
13	0.81	0.38	Classifying

14	0.84	0.31	Classifying
15	0.63	0.56	Using data to formulate models
16	0.70	0.59	Using data to formulate models
17	0.77	0.47	Experimenting

In the analyses performed for the items in the test, the average difficulty of the test items was found to be .82 and the average discrimination was found to be .54. In this case, it can be said that the test is easy in general, but its discrimination is at a sufficient level and the test can be used in this form (DeVellis, 2016; Secolsky & Denison, 2012).

The difficulty indices of all items are higher than .40. In this case, it can be interpreted that the difficulty of the items is appropriate (Hasançebi et al., 2020). When the discrimination indices are analysed, it is seen that all items had a higher discrimination than .30 and deemed to be discriminative enough (Secolsky & Denison, 2012). When the literature is examined, it is seen that the lowest discriminative skills are the basis for all other science process skills (Rezba et al., 1995; Wellington, 1989). For example, the skills with rather low discrimination indices of observing (0.34), inferring (0.31), classifying (0.31) and interpreting data (0.31) are basic science process skills that most students should have gained in the elementary school period (Çepni et al, 1997; Rezba et al., 1995). Therefore, it is thought that it is natural for the pupils to be more successful in this skill. Since the discrimination indices of the other items are higher than .30, it is considered appropriate to use them in the test (DeVellis, 2016). In order to better understand the functioning of the items in the science process skills test, distractor analysis was also performed and the selection of the options in the lower and upper groups is shown in Table 3 below.

Table 3

Distractor Analysis of the Items in the Online Science Process Skills Test

Item	Group	Option 1	Option 2	Option 3	Option 4
1	Total	77*(.928)	6 (.072)		
	Upper	22 (1.000)	0 (.000)		
	Lower	27 (.871)	4 (.129)		
	Difference	-5 (.129)	-4(-.129)		
2	Total	4 (.048)	68*(.819)		
	Upper	0 (.000)	22 (1.000)		
	Lower	2 (.065)	21 (.677)		
	Difference	-2(-.065)	1 (.323)		
3	Total	62*(.747)	11 (.133)	6 (.072)	4 (.048)
	Upper	22 (1.000)	0 (.000)	0 (.000)	0 (.000)
	Lower	15 (.484)	8 (.258)	5 (.161)	3 (.097)
	Difference	7 (.516)	-8(-.258)	-5(-.161)	-3(-.097)
4	Total	7 (.084)	54*(.651)	13 (.157)	9 (.108)
	Upper	0 (.000)	22 (1.000)	0 (.000)	0 (.000)
	Lower	5 (.161)	7 (.226)	11 (.355)	8 (.258)
	Difference	-5(-.161)	15 (.774)	-11 (-.355)	-8(-.258)
5	Total	5 (.060)	10 (.120)	64*(.771)	4 (.048)
	Upper	0 (.000)	0 (.000)	22 (1.000)	0 (.000)
	Lower	4 (.129)	8 (.258)	15 (.484)	4 (.129)
	Difference	-4(-.129)	-8(-.258)	7 (.516)	-4(-.129)

6	Total	53*(.639)	11 (.133)	10 (.120)	9 (.108)
	Upper	21 (.955)	1 (.045)	0 (.000)	0 (.000)
	Lower	12 (.387)	4 (.129)	7 (.226)	8 (.258)
	Difference	9 (.567)	-3(-.084)	-7(-.226)	-8(-.258)
7	Total	5 (.060)	68*(.819)	5 (.060)	5 (.060)
	Upper	0 (.000)	22 (1.000)	0 (.000)	0 (.000)
	Lower	2 (.065)	19 (.613)	5 (.161)	5 (.161)
	Difference	-2(-.065)	3 (.387)	-5(-.161)	-5(-.161)
8	Total	40*(.482)	18 (.217)	15 (.181)	10 (.120)
	Upper	19 (.864)	1 (.045)	1 (.045)	1 (.045)
	Lower	7 (.226)	10 (.323)	10 (.323)	4 (.129)
	Difference	12 (.638)	-9(-.277)	-9(-.277)	-3(-.084)
9	Total	7 (.084)	66*(.795)	5 (.060)	5 (.060)
	Upper	0 (.000)	22 (1.000)	0 (.000)	0 (.000)
	Lower	5 (.161)	18 (.581)	5 (.161)	3 (.097)
	Difference	-5(-.161)	4 (.419)	-5(-.161)	-3(-.097)
10	Total	60*(.723)	5 (.060)	7 (.084)	11 (.133)
	Upper	22 (1.000)	0 (.000)	0 (.000)	0 (.000)
	Lower	10 (.323)	5 (.161)	7 (.226)	9 (.290)
	Difference	12 (.677)	-5(-.161)	-7(-.226)	-9(-.290)
11	Total	5 (.060)	8 (.096)	10 (.120)	60*(.723)
	Upper	1 (.045)	0 (.000)	1 (.045)	20 (.909)
	Lower	3 (.097)	7 (.226)	6 (.194)	15 (.484)
	Difference	-2(-.051)	-7(-.226)	-5(-.148)	5 (.425)
12	Total	7 (.084)	66*(.795)	5 (.060)	5 (.060)
	Upper	0 (.000)	22 (1.000)	0 (.000)	0 (.000)
	Lower	5 (.161)	18 (.581)	5 (.161)	3 (.097)
	Difference	-5(-.161)	4 (.419)	-5(-.161)	-3(-.097)
13	Total	5 (.060)	8 (.096)	10 (.120)	60*(.723)
	Upper	1 (.045)	0 (.000)	1 (.045)	20 (.909)
	Lower	3 (.097)	7 (.226)	6 (.194)	15 (.484)
	Difference	-2(-0,051)	-7(-0,226)	-5(-0,148)	5 (0,425)
14	Total	7 (0,084)	54*(0,651)	13 (0,157)	9 (0,108)
	Upper	0 (0,000)	22 (1,000)	0 (0,000)	0 (0,000)
	Lower	5 (0,161)	7 (0,226)	11 (0,355)	8 (0,258)
	Difference	-5(-0,161)	15 (0,774)	-11 (-0,355)	-8(-0,258)
15	Total	5 (0,060)	8 (0,096)	10 (0,120)	60*(0,723)
	Upper	1 (0,045)	0 (0,000)	1 (0,045)	20 (0,909)
	Lower	3 (0,097)	7 (0,226)	6 (0,194)	15 (0,484)
	Difference	-2(-0,051)	-7(-0,226)	-5(-0,148)	5 (0,425)
16	Total	60*(0,723)	10 (0,120)	5 (0,060)	8 (0,096)
	Upper	20 (0,909)	1 (0,045)	1 (0,045)	0 (0,000)
	Lower	15 (0,484)	6 (0,194)	3 (0,097)	7 (0,226)
	Difference	5 (0,425)	-5(-0,148)	-2(-0,051)	-7(-0,226)
17	Total	5 (0,060)	5 (0,060)	7 (0,084)	66*(0,795)
	Upper	0 (0,000)	0 (0,000)	0 (0,000)	22 (1,000)

Lower	5 (0,161)	3 (0,097)	5 (0,161)	18 (0,581)
Difference	-5(-0,161)	-3(-0,097)	-5(-0,161)	4 (0,419)

When the difference of the distractors takes negative values in the distractor analysis, it indicates that more pupils in the lower-scoring group chose the distractor (the wrong answer) than in the higher-scoring group. This is a desirable feature for the test item since it means that more academically successful pupils are correctly separated from less successful pupils with the help of the item. When Table 3 is analysed, it is seen that none of the distractors in the items in the test prevented the correct answer to the question, so no change was deemed necessary (Hasançebi et al., 2020).

In order to comment on the science process skills of these pupils, descriptive statics from the data were provided in Table 4.

Table 4

Descriptive Statistics of the Data

Gender	$\bar{x}$	sd	Skewness	Kurtosis
Female	71.85	23.28	-0.80	-0.20
Male	74.35	19.27	-0.41	-0.32
Total	73.03	21.40	-0.69	-0.11

The table presents descriptive statistics of pupils' Science process skills, broken down by gender. The data suggest that on average, female pupils score slightly higher (74.35) than male pupils (71.85) on the science process skills. The standard deviation (sd) for both male and female pupils is quite large, indicating a wide range of scores. The negative skewness values for both groups suggest that there are more pupils scoring at the higher end of the test. The kurtosis values are negative for both groups, indicating a flat distribution with relatively fewer scores in the tails. Overall, the data suggest that the science process skill levels of both female and male students are high.

Table 5 shows the descriptive statistics of students' scores from the online science process skills test separately by skills.

Table 5

Descriptive Statistics of Students' Scores for Each Science Process Skill

Scientific Process Skills	$\bar{X}$	Mode	Median	Min	Max
Observation	0.93	1.00	1.00	0.00	1.00
Measurement	0.69	1.00	1.00	0.00	1.00
Saving data	0.53	1.00	1.00	0.00	1.00
Do not make inferences	0.90	1.00	1.00	0.00	1.00
Pre-cutting	0.76	1.00	1.00	0.00	1.00
Modifying and controlling variables	0.77	1.00	1.00	0.00	1.00
Classification	0.83	1.00	1.00	0.00	1.00
Using data and building models	0.71	1.00	1.00	0.00	1.00
Hypothesising	0.88	1.00	1.00	0.00	1.00
Establishing number space relations	0.60	1.00	1.00	0.00	1.00
Data interpretation	0.80	1.00	1.00	0.00	1.00
Experimentation	0.79	1.00	1.00	0.00	1.00
Decision making	0.72	1.00	1.00	0.00	1.00
Identifying variables	0.78	1.00	1.00	0.00	1.00

When Table 5 is analysed, it is seen that the students' observing, inferring, hypothesising and classifying science process skill scores have the highest average, while the lowest scores are in recording data, establishing number-space relationships, measuring and decision-making skills.

Discussion and Conclusion

Science process skills tend to be ignored in classroom assessment and evaluation due to their hands-on nature (Brotherton & Preece, 1996; Indri et al., 2020) and the tendency to measure them indirectly with skill-based multiple-choice questions within the framework of the Turkish education system (Ar et al., 2023; Çataldere, 2022; Mutlu & Özden, 2017; Ülger et al., 2022). A scientific process skills scale was devised as an economical tool in terms of being suitable for application in the online environment, useful in terms of being supported by videos, comprehensive in terms of representing each skill with at least one question, universal in terms of being formed from contexts independent of the curriculum outcomes, and valid and reliable (Table 2 and Table 3). The online science process skills test developed within the scope of this study is in parallel with the recommendations in the literature in terms of utilising the benefits provided by the internet environment (Ariely et al., 2022; Vincent-Lancrin & Van Der Vlies, 2020), shaping it with the help of expert opinions that have done important studies in the field (DeVellis, 2016; Watts & Dillon, 2022), and compatibility with the Turkish curriculum (Traynor, 2017; Traynor et al., 2020; Webb, 2007). In this respect, it can be evaluated that the test will be an economical, convenient and useful tool in terms of its use in measurement and evaluation activities in the classroom or out-of-school environments.

When the science process skill scores of the students are analysed separately (Table 5), it is seen that the students' observing, inferring, hypothesising and classifying science process skill scores have the highest average, while the lowest scores are in recording data, establishing number-space relationships, measuring and decision-making skills. This coincides with Paine's (2020) finding that students use experimental skills at a higher level and with the information supported by Sibic and Sesen (2022) that basic processes are the skills that are used more frequently and in which students have higher performance (Brotherton & Preece, 1996; Gabel, 1993; Harlen, 1999; Rezba et al., 1995). However, it should not be ignored that this situation may be related to students' prior learning, the methods, techniques or approaches used in teaching, and the differences that may arise from the learning environment or the teacher. Since cognitive, affective or kinaesthetic characteristics were not observed as variables in this screening and prediction study, the limitation that this situation may affect the results of the study has the potential to be examined in future research. As a result, since each of the students' science process skills have different averages from each other, it emerges that they should be considered as a standard that should be monitored more carefully and analysed separately since they are important outcomes of science teaching. As it can be understood from the findings of this study, it is noteworthy that the students who have reached the 8th grade level have not shown a complete performance in skills that should have been acquired at an earlier age, such as basic science process skills.

The findings of this study are consistent with the literature, which indicates that multiple-choice questions are widely used to measure science process skills (Aydoğdu, 2017; Aydoğdu et al., 2012; Bahşi̇ & Açıkgül Fırat, 2022; Ergül et al., 2011; Fathonah et al., 2018; Gill, 2019; Özçelik, 2019; Özgelen, 2012; Şensoy & Yıldırım, 2017; Şıvgın, 2019; Smith, 1995; Uysal & Cebesoy, 2022). However, there are also studies that utilized open-ended questions and activities, considering that the data collected only with multiple-choice questions would not be sufficient due to the nature of science process skills (Azizah et al., 2018; Çepni, 2004; Indri et al., 2022; Rezba et al., 1995; Rillero, 1998; Şahin et al., 2018; Serevina et al., 2018; Strong, 2013; Wu, 1994). This study's approach could be seen as unique in that it employed both open-ended and multiple-choice questions, making it a more reliable and valid instrument for assessing science process skills.

Furthermore, the study's findings revealed that the devised online science process skills test could provide science educators with accurate and efficient results when assessing pupils' science process skills. This is consistent with the literature, which highlights the importance of science process skills evaluation in science education (Fathonah et al., 2018; Gill, 2019; Özgelen, 2012; Şensoy & Yıldırım, 2017; Ülger, 2021). The test is also a web-based tool that is supported by videos that provide a more engaging and interactive experience for pupils. This approach is consistent with the literature, which highlights the importance of various learning approaches (Lederman & Stefanich, 2007; Şensoy & Yıldırım, 2017; Türkmen & Kandemir, 2011) in teaching and assessing science process skills due to the hands-on nature of those skills. Keeping in mind, these skills can be difficult to employ by students especially if the context or real-world situation is not easily visualised. For that reason, adding video-based scenarios or experiments to the assessment process may ameliorate that limitation. The development of the online science process skills test was based on the existing literature on science process skills and their assessment. The literature suggests that science process skills are essential for scientific literacy and STEM education (SESE, 1999; Tan & Temiz, 2003) and that the assessment of science process skills can provide valuable information for teachers and pupils (Ülger, 2021). However, the literature also suggests that the assessment of science process skills is challenging, as it requires the use of open-ended questions and activities that are difficult to score and analyse (Azizah et al., 2018; Çepni, 2004; Wu, 1994).

To address these challenges, the online science process skills test includes both open-ended and multiple-choice questions and is supported by videos that provide a more engaging and interactive experience for pupils. The inclusion of open-ended questions allows for the assessment of higher-order thinking skills, such as analysis, synthesis, and evaluation, which are essential for scientific inquiry and problem-solving (Mcgregor, 2007). The inclusion of multiple-choice questions allows for the assessment of lower-order thinking skills, such as recall and recognition, which are important for mastering basic scientific concepts and procedures (Brookhart, 2010). For this study, the science process skills of measuring and establishing space-number relations were assessed with open-ended questions because these skills needed to be separated from the chance success effect due to the video experiment context. The rest of the science process skills were assessed with multiple-choice items in the context of given experiment videos and thus ensured the reliability of measurement.

Implications for Practise

Overall, the development of the online science process skills test has important implications for science education. The test provides an efficient and accurate way to assess middle school pupils' science process skills, which can inform instruction and support for pupils. The use of videos in the test provides a more engaging and interactive experience for pupils, which can enhance their motivation and interest in science. Moreover, the online nature of the test allows for flexibility and accessibility, as pupils can complete the assessment at their own pace and from any location with internet access.

Furthermore, the online science process skills test can also benefit teachers and researchers. The test can help teachers identify areas of strength and weakness in their pupils' science process skills, which can inform instructional decisions and strategies. Researchers can use the test to investigate the development of science process skills over time, as well as to compare and contrast pupil performance across different populations and contexts. However, it is important to integrate alternative assessment and evaluation methods in the process of measuring skills and to measure skills as valid and reliable as possible. Performance-based tasks, direct observation and simulation tasks may be more likely to capture the nature and unique aspects of these skills. In this respect, having more than one scale used to determine students' science process skills and observing the harmony between them may also positively affect the performance of the model.

It can be suggested that longitudinal studies should be conducted to follow the development of students' science process skills over time as well as predict them, and studies should be conducted to eliminate the deficiencies in skills. It is thought that longitudinal data will allow researchers to examine the progress in students' science process skills and determine the factors contributing to the development of these skills and may provide important results about the effectiveness of different teaching strategies, the effect of the learning environment and the role of individual characteristics in the acquisition of skills. In line with the unique characteristics and requirements of each science process skill, it is thought that the development of assessment strategies specific to these skills will contribute to the literature. In this way, each science process skill can be measured separately, and the nature of these science process skills can be understood more easily.

Limitations of the Study

While the pilot study provides promising evidence of the validity and reliability of the online science process skills test supported by videos, there are some limitations that need to be acknowledged. First, the sample size for the pilot study was limited to 114 middle school pupils, which may not be representative of the larger pupil population or different groups of pupils. Second, the study is limited to fourteen core science process skills (Çepni et al., 1997) which were assessed in the study. Finally, the study does not include a comparison with other existing science process skills assessments, which limits our ability to draw conclusions about the unique contributions of the online test. These limitations suggest that further research is needed to confirm the validity and generalizability of the online science process skills test.

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Appendix 1. Examples from the Online Science Process Skill Test

1. deney

https://www.youtube.com/watch?v=vUrWJBGRE7I

Yukarıda içerisinde eşit miktarda su bulunan cam balonlar ile gerçekleştirilen deneyi dikkatlice izleyin. Daha sonra bu videoyla ilgili sorular yanıtlayacaksınız. Istediğiniz zaman geri dönüp videoyu tekrar izleyebilirsiniz.

1. 1. deneye ait videoyu dikkatlice izleyin. Hangi şişe diğerinden daha önce boşalıyor? *

- İçerisinde uzun pipet olan
- İçerisinde kısa pipet olan

2. 1. deneye ait videoyu dikkatlice izleyin. İlk boşalan şişenin boşalması, ters çevrildiği andan itibaren kaç saniye sürüyor?

3. İlk boşalan şişenin boşalması için geçen süreyi doğru hesaplayabilmek için yapılması gereken işlemi ve sonucunu yazınız. (Örneğin "A-B=C" şeklinde)

4. İzlediğiniz deneye dayalı olarak aşağıdaki verilenlerden hangisi veya hangileri söylenebilir?

- Kısa pipet uzun pipete göre daha incedir.
- Uzun pipetteki suyun akış hızı daha fazladır.
- Uzun pipetli şişedeki suyun yoğunluğu daha fazladır.
- Kapta biriken sıvının büyük kısmı kısa pipetli şişeden gelmiştir.

5. Yukarıda yapılan deneye içinde aynı cins eşit miktar sıvı bulunan, ilk iki şişedekinden daha uzun pipet takılmış üçüncü bir şişe eklenseydi, üçüncü şişedeki sıvının boşalması ne kadar sürebilirdi?

- 20-27 saniye arası
- 28-34 saniye arası
- 35-45 saniye arası
- 45-54 saniye arası