JOURNAL OF EDUCATIONAL RESEARCH & PRACTICE

Journal of Educational Research & Practice
2023, Volume 12, Issue 1, Pages 123–141
DOI: 10.5590/JERAP.2023.13.1.10

Original Research WALDEN UNIVERSITY

Science Curriculum Requirements: Science Process Skills in Textbook Activities

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Abstract

Science textbooks play an important role in making scientific knowledge and applications available to learners. In most countries, science curriculum expects to cultivate scientifically literate individuals who are able to use science process skills. Critical analysis of textbooks is therefore crucial to determine whether they can facilitate this outcome. The purpose of this study is to find out to what extent science process skills are included in the activities of elementary and middle school science textbooks in Turkey. A total of 304 activities in six science textbooks were analyzed. A content analysis was employed to determine the frequency and percentage of science process skills in the activities. The results indicate that observing, collecting information and data, recording data, and interpreting and drawing conclusions receive the most emphasis in the activities at all grade levels. Measuring, estimating, predicting, processing and model creating, determining variables, knowing and using experimental materials and tools, and designing experiments are either the least frequently found science process skills or are included in none of the activities. This suggests textbooks focus more on basic science process skills rather than on high-level, causal, and experimental skills.

Keywords: *science process skills, textbook activities, document analysis, elementary and middle school*

Date Submitted: December 31, 2022 | **Date Published:** May 11, 2023

Recommended Citation

Özalp, D. (2023). Science curriculum requirements: Science process skills in textbook activities. *Journal of Educational Research and Practice, 13,* 123–141. https://doi.org/10.5590/JERAP.2023.13.1.10

Introduction

In order to become scientifically literate individuals, students need science process skills (SPS). SPS have been defined as “a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of scientists” (Padilla, 1990, p. 1). SPS are known as the skills that are used in the procedures of experiments, scientific investigations, or scientific inquiry (Harlen, 1999). They are intellectual skills that are used in all scientific disciplines (National Science Teaching Association [NSTA], 2000) and are therefore essential to learning with understanding in science classes and applying that learning in the greater world. The effectiveness of SPS in science learning has been emphasized in several studies (Chang & Weng, 2000; Turpin & Cage, 2004). By practicing SPS, students learn science more easily, take responsibility for their own learning, and learn research methods (Karamustafaoğlu, 2003). SPS help students to develop higher-order thinking, so that they have meaningful learning experiences (Lee et al., 2002). Thus, science education should aim to develop individuals' SPS (Harlen, 2000).

In most countries, textbooks still play a crucial role in guiding teachers and developing students' SPS. This study aims to determine the extent to which SPS are included in the activities of elementary and middle school science textbooks in Turkey. Textbooks are crucial to education, reflecting how curriculum is implemented in practice. They affect teachers' decisions on which strategies and techniques should be used in teaching the content (Caravita et al., 2008; Lee & Catling, 2015). Developing textbooks as teaching sources is considered one of the basic and effective ways to revise and apply required practices (Graves & Murphy, 2000). Textbooks are therefore still considered important teaching materials in primary and secondary school education (Chakraborty & Kidman, 2021; Lee et al., 2020).

Textbooks are written in accordance with themes, objectives, content, and outcomes stated in the current curriculum. One of the aims of the Turkish science curriculum that was renewed in 2018 is "Helping the students to understand how scientific knowledge is created by scientists, and how this knowledge is used in new research" (Ministry of National Education [MoNE], 2018, p. 9). Following from that, two learning areas (knowledge and skills) were determined necessary for the science course, and they were divided into sub-areas. The sub-areas of knowledge are defined as knowledge of creatures and life, matter and nature, physical events, and earth and universe. The sub-areas of skills are science process skills (SPS), engineering and design skills, and life skills. SPS were clearly listed in the curriculum published in 2005 and were also emphasized in the 2018 curriculum. These SPS are observing, determining variables, comparing-classifying, designing experiments, recognizing and using experimental materials and tools, measuring, collecting information and data, recording data, data processing and model creating, making inferences, estimating, predicting, interpreting and drawing conclusions, and presenting findings (MoNE, 2005, 2018).

In Turkish curriculum, SPS were classified into three categories: planning and starting, practicing, and analyzing and drawing conclusions. Planning and starting includes observing, comparing-classifying, making inferences, estimating, predicting, and determining variables; practicing includes designing experiments, recognizing and using experimental materials and tools, measuring, collecting information and data, and recording data; analyzing and drawing conclusions includes data processing and model creating, interpreting and drawing conclusions, and presenting findings (MoNE, 2005). In this study, this classification was used to analyze and discuss the extent to which elementary and middle school science textbooks include SPS.

Literature Review

Science textbooks play an important role in making scientific knowledge available to learners (Villaverde, 2003). Analysis and evaluation of textbooks based on several dimensions are needed in order to use textbooks appropriately and so to reach the purpose of education (Dikmenli, 2015). In the literature, science textbooks have been analyzed from different perspectives, such as the nature of science (Ali et al., 2017; Chiappetta & Fillman, 2007; Ramnarain & Padayachee, 2015; Vesterinen et al., 2013), history (Ma & Wan, 2017), culture (Balfakih, 2013; BouJaoude & Noureddine, 2020), linguistics (Dimopoulos et al.,2005; Eltinge & Roberts, 1993), visuals (Gültekin & Nakiboğlu, 2015; Postigo & López-Manjón, 2019; Stylianidou & Ogborn, 2002), misconceptions (Kaltakçı-Gürel & Eryılmaz, 2013; King, 2010; Sanger & Greenbowe, 1999), Bloom's taxonomy (Akcay et al., 2018; Zorluoglu et al., 2021), and environmental education (Salmani et al., 2015; Sharma & Buxton, 2015).

In a national context, Turkish middle school science textbooks have been analyzed for SPS. In general, studies reported the most and the least frequent SPS in either one unit of the textbook or in the activities of all units. Aslan (2015) found that activities in science textbooks mostly included skills that are used to plan or start a scientific process. Skills such as determining, changing, and controlling variables were either the least frequent or not included at all. Similarly, other studies found that basic skills were most often included in activities. For instance, Öztürk and Karademir's (2017) study indicated that an activity related to the excretory system prepared for the fifth-grade science applications course included observing, measuring, classifying, recording data, identifying variables, interpreting and drawing conclusions, and presentation skills. They also stated that students' SPS were improved through engaging in this activity, so they recommended the activity as a good example for teachers to use to improve students' SPS. In another study, Şahin et al. (2016) determined that some SPS used during the implementation of activities in one unit of the textbook were different from the SPS that are specified for that unit in the curriculum. They found that SPS such as interpretation and conclusion, estimation, inference, comparison, classification, collecting information, and presentation were used in the activities, although the curriculum did not specify them for these activities in the textbook. This suggests that SPS used in the implementation of activities could be more than those expected in the curriculum. In addition, studies indicated that as grade level progresses from sixth to eighth, the close-ended nature of basic skills increased in the textbooks (Yıldız-Feyzioğlu & Tatar, 2012) and that observation and data collection were the most frequent skills in fifth-grade science textbook activities (Ceğer & Aydoğdu, 2017).

In the international literature, as well, science textbooks have been analyzed for SPS. For instance, Antrakusuma et al. (2017) analyzed three Indonesian chemistry textbooks, and the results showed that while observing, predicting, classifying, applying, planning experiments, manipulating materials and equipment, finding conclusions, and communicating were the most frequent SPS, asking questions and hypothesizing were not included. Similarly, Chakraborty and Kidman (2021) found that the Bangladeshi science textbooks they examined mostly included observing, recording data, and communication skills, but did not include questioning and constructing arguments skills. Another study conducted in Lebanon indicated that basic skills were included more than integrated skills. In addition, while observing and inferring were the most prominent skills, designing experiments, formulating models, and using numbers were the least prominent (Zeitoun & Hajo, 2015). Aziz and Zain's (2010) study of Yemeni physics textbooks indicated similar results. The three textbooks they considered focused more on basic SPS than on integrated SPS. Observing, experimenting, interpreting data, and defining operations were the most frequently found integrated SPS, but measuring, predicting, and hypothesizing were not included in some textbooks. Another study of Korean physics textbooks showed that constructing explanations and designing solutions were the most widely used SPS, whereas asking questions and defining problems were scarcely used (Lee & Choi, 2018).

Purpose and Rationale of the Study

Elementary school science in Turkey includes the third and fourth-grade levels. Studies that have been conducted on SPS in Turkish science textbooks so far have analyzed middle and high school science textbooks but not the third- and fourth-grade textbooks. Besides, these studies were carried out before the science curriculum was renewed in 2018. In Turkey, textbooks are approved for a period of 5 years, so elementary and middle school textbooks that were written before the 2018 curriculum was implemented are not currently in use. The textbooks selected for this study were published after 2018 and are currently in use in elementary and middle schools. Their learning objectives, content, and themes are different from those of textbooks published before the current curriculum. Since science education aims to cultivate scientifically literate individuals, a study is required to find out the extent to which the curriculum is reflected in current textbooks. This research therefore aimed to find out to what extent SPS are included in elementary and middle school science textbook activities and how they are represented. I hope that this research will make an important contribution to the arrangement and development of elementary and middle school science textbooks yet to be written and published. Additionally, findings regarding which SPS are included or ignored in these activities, as well as the recommendations made based on the results of this research and international studies, offer insights into issues that should be considered in the development of science textbooks in other countries. This research attempts to provide an answer to the following research question:

1. To what extent are SPS included in the activities of elementary and middle school science textbooks in Turkey?

Methods

Research Design

In this research, document analysis was used to provide in-depth information about the extent to which SPS are represented in activities in Turkish elementary and middle school science textbooks. Document analysis is used for reviewing and evaluating documents to provide empirical evidence for research problems (Corbin & Strauss, 2008), and it can be used as a single method in a study or as one of the components of a mixed methods study (Bowen, 2009; Frey, 2018).

The Science Textbooks and Analysis of the Activities

The activities in two elementary (third–fourth grades) and four middle school (fifth–eighth grades) science textbooks were analyzed for this study. The science textbooks were prepared in accordance with the science curriculum approved by the Ministry of National Education in 2018. They are still used in primary and middle schools in Turkey. Each textbook included seven units and each unit included a different number of activities, as can be seen in the findings section. Textbooks published before the curriculum change were not selected, since they are not currently in use in the schools.

The activities in the textbooks were analyzed based on the SPS required in the 2018 science education curriculum. These are: observing, comparing-classifying, making inferences, predicting, estimating, determining variables, designing experiments, recognizing and using experimental materials and tools, collecting information and data, recording data, measuring, data processing and model creating, interpreting and drawing conclusions, and presenting findings (MoNE, 2005, 2018). The science education curriculum provided the learning objectives for each science process skill. Those learning objectives include actions students should take in practicing the SPS. Based on those objectives, definitions were created for each SPS and used in the categorization of the activities. The definitions and example expressions from the activities for each science process skill can be seen in Table 1.

Table 1. *SPS, Definitions, and Example Expressions From the Activities* (MoNE, 2005)

Category	SPS	Definition	Example expressions
Planning and starting	Observation	Using five senses in observation to determine the physical properties of the objects and events.	Observe … entities around you. Close your eyes and try to feel what … .
	Comparison-classification	Classifying objects or events through identification of their qualitative and quantitative properties. Comparing objects or events through identification of similarities and differences between their properties.	Classify the substances listed above …. Is there a difference between the … .
	Making inferences	Providing meaningful explanations for the reasons of observed events.	Please explain the reasons for … ? Please explain why … ?
	Prediction	Proposing ideas about possible future outcomes based on observation, inference, or experimentation.	Indicate what effects … will have on … .
	Estimation	Proposing ideas about approximate values for quantities of objects or events.	At the end of fifteen minutes, estimate the temperature values … . Estimate what will be the value of … .
	Determining variables	Identifying dependent, independent, and controlled variables in a given event.	Explain the dependent, independent, and controlled variables … .
Practicing	Designing experiments	Proposing an experimental design in order to test a prediction.	How can you prove that … ? Show the experiment you should do for … .
	Recognizing and using experimental materials and tools	Selecting and using materials and tools in order to do an experiment in an appropriate way under the supervision of the teacher.	Use the listed materials … . Use the beaker to boil … .
	Measuring	Recognizing and using simple measuring tools to determine magnitudes and sizes in appropriate units.	Measure the value of … . Use the dynamometer to measure … .
	Information and data collection	Collecting information and data using observation, experimentation, or printed or technological sources.	Observe the water … and record … temperature values … .
	Recording data	Recording the data obtained through observations and experiments by using different written or visual forms.	Observe … around you and write them in the table below. Record the values … .

Category	SPS	Definition	Example expressions
Analyzing and drawing conclusion	Data processing and model creating	Analyzing the data obtained from experiments and observations in different quantitative ways, using visuals, and creating models.	Draw a temperature–time graph ... . Prepare a model based on ... .
	Interpretation and drawing conclusion	Interpreting data and models and expressing conclusions based on the patterns and relationships in the findings.	Explain how there is a relationship between ... . How the .... changed in this situation/experiment
	Presenting findings	Presenting and sharing the results of the observations and experiments by using oral, written, and/or visual materials.	Present your work/experiment ... . Share the observation results with ... .

In the analysis, each sentence in the activities was read carefully, and the actions that students should take in these sentences were compared with the definitions of SPS. The actions that correspond to the definitions were categorized under the appropriate SPS. The pre-determined categories were the SPS outlined in the science curriculum. After examining and categorizing each activity, frequency values and percentages were calculated for all the skills.

Two different methods were followed to ensure the reliability of the analysis. First, the researcher categorized the content in all the activities again one month after the first categorization. The comparison indicated that there is 95% similarity between the two analyses. Second, 10% of the data units were randomly selected for intercoder reliability (O'Connor & Joffe, 2020). Since there are 304 activities in this study, a total of 30 activities (five activities from each textbook) were randomly selected and categorized by another researcher, who has a PhD in science education. The reliability coefficient was found to be 0.92, suggesting there is perfect agreement between the categorization of both researchers (Landis & Koch, 1977). Inconsistencies between the categorization of both researchers were discussed, resolved, and required revisions were made in all the analyses.

Results

SPS in the Third-Grade Science Textbook Activities

There are seven units and 41 activities in the third-grade science textbook. The activities include 172 SPS. The analysis indicates that observing, collecting information and data, recording data, interpreting, and drawing conclusions, are the most frequent SPS. Comparing–classifying, measuring, making inferences, estimating, predicting, data processing and model creating, and presenting findings are the least frequent SPS. Predicting is present in only one of the science activities. Determining variables, recognizing and using experimental materials and tools, and designing experiments are not present in the activities (Table 2).

Table 2. *Frequencies of SPS in the Third-Grade Science Textbook Activities*

	SPS													
Units	Observing	Comparing–classifying	Measuring	Making inferences	Estimating	Predicting	Collecting information and data	Recording data	Data processing and model creating	Interpreting and drawing conclusions	Determining variables	Recognizing and using experimental materials and tools	Designing experiments	Presenting findings
Let's Know Our Planet	5	1	0	2	1	0	4	4	3	2	0	0	0	0
Our Five Senses	9	1	1	2	6	1	3	2	1	6	0	0	0	1
Let's Know Force	6	1	0	1	0	0	5	6	0	5	0	0	0	2
Let's Know Matter	4	1	0	0	1	0	4	4	0	3	0	0	0	0
Lights and Sounds in Our Environment	9	4	2	5	2	0	9	9	0	9	0	0	0	1
Journey to The World of Living	2	4	0	1	0	0	2	2	0	3	0	0	0	2
Electrical Vehicles	1	1	0	0	0	0	0	2	0	2	0	0	0	2
Total	36	13	3	11	10	1	27	29	4	30	0	0	0	8

SPS in the Fourth-Grade Science Textbook Activities

There are seven units and 40 activities in the fourth-grade textbook. The activities include 185 SPS. The analysis indicates that observing, comparing–classifying, collecting information and data, recording data, interpreting and drawing conclusions, are the most frequent SPS. Measuring, making inferences, estimating, predicting, data processing and model creating, recognizing and using experimental materials and tools, designing experiments, and presenting findings are the least frequent SPS. Predicting is present in only one of the science activities. Determining variables is not present in the activities (Table 3).

Table 3. *Frequencies of SPS in the Fourth-Grade Science Textbook Activities*

	SPS													
Units	Observing	Comparing–classifying	Measuring	Making inferences	Estimating	Predicting	Collecting information and data	Recording data	Data processing and model creating	Interpreting and drawing conclusions	Determining variables	Recognizing and using experimental materials and tools	Designing experiments	Presenting findings
Earth's Crust and Movements of Earth	4	2	1	1	1	0	2	2	2	2	0	0	0	1
Our Nutrition/Living Beings and Life	5	2	0	3	0	0	5	2	1	3	0	1	0	3
Effects of Force/Physical Events	8	4	1	2	1	0	8	7	0	3	0	0	0	2
Properties of Matter	15	5	4	2	0	1	12	10	2	13	0	2	2	3
Lighting and Sound Technologies	5	2	1	1	0	0	5	3	0	5	0	0	0	2
Human and Environment	0	0	0	0	0	0	1	1	0	1	0	0	0	2
Simple Electrical Circuits	1	0	0	1	1	0	1	1	0	1	0	0	0	0
Total	38	15	7	10	3	1	34	26	5	28	0	3	2	13

SPS in the Fifth-Grade Science Textbook Activities

There are seven units and 69 activities in the fifth-grade textbook. The activities included 242 SPS. The analysis indicates that observing, comparing–classifying, making inferences, collecting information and data, recording data, and interpreting and drawing conclusions are the most frequent SPS. Measuring, estimating, predicting, data processing and model creating, determining variables, recognizing and using experimental materials and tools, designing experiments, and presenting findings are the least frequent SPS. In addition, predicting is present in only one of the science activities (Table 4).

Table 4. *Frequencies of SPS in the Fifth-Grade Science Textbook Activities*

	SPS													
Units	Observing	Comparing–classifying	Measuring	Making inferences	Estimating	Predicting	Collecting information and data	Recording data	Data processing and model creating	Interpreting and drawing conclusions	Determining variables	Recognizing and using experimental materials and tools	Designing experiments	Presenting findings
Sun, Earth and Moon	7	5	2	1	1	0	3	1	7	6	0	0	0	3
World of Living Beings	4	2	0	2	1	0	4	4	1	2	0	0	0	1
Measuring Force	7	6	3	3	1	1	7	3	3	3	0	2	0	2
Matter and Change	15	3	6	5	1	0	13	6	2	5	0	1	0	1
Spread of Light	8	3	2	6	1	0	6	3	1	3	0	0	1	0
Human and Environment	5	4	1	4	1	0	5	2	0	6	0	1	0	1
Elements of Electrical Circuit	3	2	0	0	0	0	2	2	3	3	2	2	2	1
Total	49	25	14	21	6	1	40	21	17	28	2	6	3	9

SPS in the Sixth-Grade Science Textbook Activities

There are seven units and 42 activities in the sixth-grade textbook. The activities include 193 SPS. The analysis indicates that observing, comparing–classifying, collecting information and data, recording data, interpreting and drawing conclusions, and presenting findings are the most frequent SPS. Measuring, making inferences, estimating, predicting, data processing and model creating, determining variables, recognizing and using experimental materials and tools, and designing experiments are the least frequent SPS (Table 5).

Table 5. *Frequencies of SPS in the Sixth-Grade Science Textbook Activities*

	SPS													
Units	Observing	Comparing–classifying	Measuring	Making inferences	Estimating	Predicting	Collecting information and data	Recording data	Data processing and model creating	Interpreting and drawing conclusions	Determining variables	Recognizing and using experimental materials and tools	Designing experiments	Presenting findings
The Solar System and Eclipses	2	0	0	0	0	0	3	1	3	2	0	0	0	3
Systems in Our Body	4	0	1	2	1	0	3	1	3	4	0	0	0	2
Force and Movement	2	2	2	0	1	0	2	1	0	2	0	0	0	0
Matter and Heat	7	7	3	3	3	1	9	6	5	9	0	1	0	4
Sound and Its Features	5	5	0	2	2	0	7	2	1	7	2	2	2	2
Systems in Our Body and Health	2	1	0	0	1	0	7	2	1	5	0	1	0	5
Transmission of Electricity	4	4	0	0	1	1	4	4	0	3	0	3	0	0
Total	26	19	6	7	9	2	35	17	13	32	2	7	2	16

SPS in the Seventh-Grade Science Textbook Activities

There are seven units and 42 activities in the seventh-grade textbook. The activities include 189 SPS. The analysis indicates that observing, comparing-classifying, collecting information and data, recording data, interpreting and drawing conclusions, and presenting findings are the most frequent SPS. Measuring, making inferences, estimating, data processing and model creating, determining variables, and recognizing and using experimental materials and tools are the least frequent SPS. Determining variables is present in only one of the activities. In addition, predicting and designing experiments are not present in the activities (Table 6).

Table 6. *Frequencies of SPS in the Seventh-Grade Science Textbook Activities*

	SPS													
Units	Observing	Comparing–classifying	Measuring	Making inferences	Estimating	Predicting	Collecting information and data	Recording data	Data processing and model creating	Interpreting and drawing conclusions	Determining variables	Recognizing and using experimental materials and tools	Designing experiments	Making presentation
The Solar System and Beyond	2	2	2	1	1	0	3	1	2	3	0	0	0	4
Cell and Divisions	3	3	0	1	1	0	4	1	2	5	0	0	0	3
Force and Energy	3	3	1	2	0	0	2	1	1	3	0	1	0	1
Pure Substances and Mixtures	5	4	1	2	2	0	8	1	2	9	0	1	0	10
Interaction of Light with Matter	8	7	2	2	1	0	10	6	3	8	0	2	0	3
Reproduction & Growth	3	2	1	0	0	0	3	3	0	2	1	1	0	2
Electrical Circuits	2	2	1	0	0	0	2	1	1	1	0	1	0	1
Total	26	23	8	8	5	0	32	14	11	31	1	6	0	24

SPS in the Eighth-Grade Science Textbook Activities

There are seven units and 70 activities in the eighth-grade textbook. The activities include 286 SPS. The analysis indicates that observing, comparing–classifying, making inferences, collecting information and data, interpreting and drawing conclusions, and presenting findings are the most frequent SPS. Measuring, estimating, predicting, recording data, data processing and model creating, determining variables, recognizing and using experimental materials and tools, and designing experiments are the least frequent SPS. In addition, predicting is not present in the activities. Determining variables and designing experiments are present in only one of the activities (Table 7).

Table 7. *Frequencies of SPS in the Eighth-Grade Science Textbook Activities*

	SPS													
Units	Observing	Comparing–classifying	Measuring	Making inferences	Estimating	Predicting	Collecting information and data	Recording data	Data processing and model creating	Interpreting and drawing conclusions	Determining variables	Recognizing and using experimental materials and tools	Designing experiments	Presenting findings
Seasons and Climate	3	2	2	2	0	0	4	1	2	3	0	0	0	4
DNA and Genetic Code	3	3	1	2	3	0	5	2	2	4	0	0	0	4
Pressure	3	3	1	2	0	0	5	1	1	6	0	3	0	3
Matter and Industry	14	11	7	7	2	0	14	6	5	16	1	4	0	7
Simple Machines	4	2	2	2	0	0	3	2	2	4	0	0	0	2
Energy Trans. and Environ.	7	7	2	6	1	0	11	3	2	11	0	5	1	9
Electric Charge and Energy	5	0	0	3	0	0	4	1	2	4	0	0	0	5
Total	39	28	15	24	6	0	46	16	16	48	1	12	1	34

SPS in the Activities of All Grade Levels

As seen in Table 8, observing, collecting information and data, and interpreting and drawing conclusions are the most frequent SPS in all grades. While the percentage of observing starts to decrease in the sixth grade, the percentages of collecting information and data and interpreting and drawing conclusions do not show a dramatic change from elementary to middle school. In addition, although recording data is among the most frequent skills in the third and fourth grades, its percentage starts to decrease in the fifth-grade textbook.

The analysis also indicates that although comparing–classifying, measuring, making inferences, data processing and model creating, and presenting findings are among the least frequent skills in elementary textbooks, their percentages increase in middle school textbooks. Similarly, the percentage of recognizing and using experimental materials and tools increases in middle school, but very little, and it is still one of the least frequent skills in all grade levels. Percentages of determining variables, designing experiments, estimating, and predicting, are the lowest in both elementary and middle school textbooks.

Table 8. *The Percentages and Frequencies of SPS in Each Grade Level*

	SPS	3rd grade	4th grade	5th grade	6th grade	7th grade	8th grade
Planning and starting	Observing	21% (36)	21% (38)	20% (49)	13% (26)	14% (26)	14% (39)
	Comparing-classifying	8% (13)	8% (15)	10% (25)	10% (19)	12% (23)	10% (28)
	Making inferences	6% (11)	5% (10)	9% (21)	4% (7)	4% (8)	8% (24)
	Estimating	6% (10)	2% (3)	2% (6)	5% (9)	3% (5)	2% (6)
	Predicting	1% (1)	1% (1)	0.4% (1)	1% (2)	0% (0)	0% (0)
	Determining variables	0% (0)	0% (0)	1% (2)	1% (2)	1% (1)	0% (0)
Practicing	Collecting information and data	16% (27)	18% (34)	17% (40)	18% (35)	17% (32)	16% (46)
	Recording data	17% (29)	14% (26)	9% (21)	9% (17)	7% (14)	6% (16)
	Measuring	2% (3)	4% (7)	6% (14)	3% (6)	4% (8)	5% (15)
	Recognizing and using experimental materials and tools	0% (0)	2% (3)	2% (6)	4% (7)	3% (6)	4% (12)
	Designing experiments	0% (0)	1% (2)	1% (3)	1% (2)	0% (0)	0,35% (1)
Analyzing and drawing conclusion	Interpreting and drawing conclusion	17% (30)	15% (28)	12% (28)	17% (32)	16% (31)	17% (48)
	Presenting findings	5% (8)	7% (13)	4% (9)	8% (16)	13% (24)	12% (34)
	Data processing and model creating	2% (4)	3% (5)	7% (17)	7% (13)	6% (11)	6% (16)

Discussion and Conclusion

SPS are important to cultivating scientifically literate individuals. Since textbooks reflect how the curriculum is implemented in practice, in this study, content analysis was used to find out to what extent elementary and middle school science textbooks include the SPS required by the 2018 Turkish curriculum. As stated earlier, the Turkish curriculum classifies SPS in three categories: planning and starting, practicing, and analyzing and drawing conclusions. Planning and starting includes observing, comparing-classifying, making inferences, estimating, predicting, and determining variables; practicing includes designing experiments, recognizing and using experimental materials and tools, measuring, collecting information and data, and recording data; analyzing and drawing conclusions includes data processing and model creating, interpreting and drawing conclusions, and presenting findings (MoNE, 2005).

The results of this study indicate that SPS in in the third-grade textbook in the planning and starting category are, ordered from the highest frequency to the lowest, observing, comparing–classifying, making inferences, estimating, predicting, and determining variables. Interestingly, this order is the same in all the other grade levels, suggesting that science textbooks order their emphasis on SPS similarly in different grade levels. This conclusion is the same for the SPS in the practicing and analyzing and drawing conclusions categories. At all grade levels, from the highest to the lowest frequency, SPS in the practicing category are ordered thus: collecting information and data, recording data, measuring, recognizing and using experimental materials and tools, and designing experiments. At all grade levels, in the analyzing and drawing conclusions category, from highest to lowest frequency, SPS are ordered thus: interpreting and drawing conclusions, presenting findings, and data processing and model creating.

The results of this study also indicate that the skills of observing, comparing-classifying, collecting information and data, and interpreting and drawing conclusions are emphasized the most in the activities of all grades. This suggests that the planning and starting, practicing, and analyzing and drawing conclusions categories are all represented with at least one SPS that is emphasized the most in the activities of elementary and middle school science textbooks. Yıldız-Feyzioğlu and Tatar's (2012) study showed similar results. They found that Turkish middle school science textbooks focused most on observing, collecting information and data, recording data, and interpretation.

The present study shows that estimating, predicting, determining variables, recognizing and using experimental materials and tools, designing experiments, and processing and model creating are emphasized the least in the activities of all grade levels. Although making inferences is emphasized more in the fifth and eighth grades, it is still among the least emphasized skills in the other grade levels. This suggests that some of the SPS in all three categories are less emphasized in textbook activities. Especially, the following SPS in the planning and practicing categories are much less involved in the activities: predicting, determining and controlling variables, designing experiments, and recognizing and using experimental materials and tools. Since Çepni et al. (1997) state that these skills are used to conduct experiments, it can be concluded that experimental skills are rarely included in the activities of not only elementary school textbooks, but also middle school textbooks in this study. Similar results were found in Akçay's (2011) study. They found that the activities in seventh-grade Turkish science textbooks included less causal and experimental skills. High school science textbooks also have a similar trend in science process skills. For instance, Şen and Nakiboğlu (2012) determined that prediction, measuring, experiment verification, data processing and modeling, determining variables, and designing experiments were the least frequent skills in the activities of Turksish high school chemistry textbooks. Based on those these findings, it is recommended that in the science textbooks, more emphasis must be placed on the causal and experimental SPS that will enable students to engage in more complex practices of doing science.

Moreover, this study indicates that most of the activities involving experiments do not require students to actually design an experiment and determine variables; instead, they only encourage them to conduct an experiment. This is why the skill of recognizing and using experimental materials and tools, which is normally used in both conducting and designing experiments, is identified in more activities, as opposed to the skills of designing experiments and determining variables. Designing an experiment requires students to propose an experimental design in order to test a prediction. The activities in the textbooks, however, provide the students with all the materials rather than requiring students to propose an experimental design themselves. They require students to follow all the presented steps, one by one, from the beginning to the end of the activity, without encouraging them to think of how they could design an experiment to reach results. Of course, in class applications, teachers may encourage students to design experiments. Depending on teachers' abilities and teaching strategies, they can revise the application of the activities. Since this study does not explore classroom applications, it is recommended that, in the future, research science classrooms should be observed to see whether and how teachers revise their application of activities.

One of the interesting results of this study is that although measuring is one of the important SPS in the practicing category, low emphasis is given to it in all grade levels. Few activities in this study required students to use simple measurement tools and express magnitudes in units. This is true in other countries. Previous studies indicate that measuring was among the least frequent skills in third-, fourth- and fifth-grade Bangladeshi science textbooks (Chakraborty & Kidman, 2021) and was even neglected in an 11th-grade Yemeni physics textbook (Aziz & Zain, 2010). This suggests there is a general tendency to place low emphasis on the skill of measuring in science textbooks used in various countries. I, therefore, suggest that textbook writers should place more emphasis on this skill, since it is also important in the development of other SPS, such as collecting and analyzing data.

The results of this study also indicate that, while the emphasis given to observing and recording data skills starts to decrease in the activities of sixth- and fifth-grade textbooks respectively, data processing and model creating and presentation skills start to receive more emphasis in the fifth and seventh grades, respectively. In other words, two skills in the planning and starting and practicing categories lose emphasis, but two skills in analyzing and drawing conclusions receive more emphasis in middle school. As it is known, an investigation process starts with using skills in the planning and starting category, continues with using skills in the practicing category, and ends with using skills in the analyzing and drawing conclusion category. Therefore, it is recommended that the emphasis given to the skills in these respective categories be increased gradually from elementary to middle school. Skills in planning and starting can be emphasized more in the third and fourth grades, skills in the practicing category can be emphasized more in the fifth and sixth grades, and skills in the analyzing and drawing conclusions category can be emphasized more in the seventh and eighth grades. The present study shows that SPS in those three categories are not gradually emphasized as the grade level increases. Although presenting findings increases in the seventh grade, this is not true for other skills in those three categories.

The results of this research and previous studies indicate that activities in science textbooks focus on some SPS less than on others. Some SPS are not included in the activities at all. Although it is not an expectation to place the same level of emphasis on all SPS, some level of emphasis on each SPS is expected. Therefore, textbooks should be designed in a way to improve all the skills that are used in science activities. Of course, textbooks are not the only way to improve students' skills, but they are important sources of education, since they help to implement the curriculum in practice (Graves & Murphy, 2000), and they provide teachers with strategies and techniques that should be used in teaching the content (Caravita et al., 2008; Lee & Catling, 2020). Preparation of science textbooks is clearly crucial to cultivating scientifically literate individuals. The results of the study suggest that science textbook writers must be concerned with meeting the expectations and objectives of a given curriculum. In the preparation of activities especially, writers should take care to include all SPS required by the curriculum, so as to engage students in those skills at a sufficient level. These activities should be reviewed carefully to determine whether there is a lack of emphasis among the SPS and, if so, revised to ensure they satisfy all requirements.

Limitations

The findings of this study are limited to elementary and middle school textbooks. Future research can evaluate high school science textbooks in Turkey prepared according to the 2018 curriculum. Comparative analysis of science textbooks belonging to the same grade levels in different countries and the extent to which they contain SPS can be performed using the same criteria. A more general judgment could thereby be made regarding tendencies for inclusion of SPS in science textbooks around the world.

Declaration

The author declares that there is no conflict of interest.

This article does not contain any studies with human or animal participants.

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