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Pre-service Science and Primary School Teachers' Identification of Scientific Process Skills

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Abstract The purpose of this study was to conduct a comparative analysis of pre-service primary school and science teachers' identification of scientific process skills. The study employed the survey method, and the sample included 95 pre-service science teachers and 95 pre-service primary school teachers from the Faculty of Education at Recep Tayyip Erdoğan University in Turkey. All participating students were in their third year. A 24-question Scientific Process Skills Test was employed as the data collection tool. Students were asked to choose the correct answer for each question and specify which scientific process skills were measured with the answer. The analysis of the students' answers involved tabulating the correct answers given for each question and students' answers concerning the scientific process skill measured by the answer along with their frequencies. The analysis indicated that pre-service science teachers gave more correct answers than pre-service primary school teachers in the first section of the study, which made them more successful overall. Considering that the second section of the test included questions about acquisitions, the pre-service teachers, who were from two different departments, provided similar answers, and no significant difference was found. Furthermore, the pre-service teachers from both departments used many skills interchangeably.

Keywords Scientific Process Skills, Pre-service Primary School Teachers, Pre-service Science Teachers

1. Introduction

Many daily situations that we encounter are related to physics, biology, or chemistry. If individuals associate the events they experience with what they learn at school, it will contribute much to their scientific literacy. If this association cannot be achieved in schools, individuals may not acquire the knowledge and skills necessary for an easier life dominated by technology [1]. This association can be established in the most basic way by completing science courses in primary school, during which students learn their milieu, natural events, and scientific advancements through basic concepts, principles, and generalizations. In this way, they also acquire scientific thinking and problem-solving skills [2]. Rather than learning concepts, theories, and laws in science courses, it is vital for students to learn how to apply such scientific issues to daily life. Therefore, it is necessary for them to learn scientific process skills that help them construct scientific knowledge [3].

Changes in the curricula in many countries have attached importance to a constructivist approach, the nature of science, science-technology-society-environment (STSE) relationships, and in particular scientific process skills. In this sense, the purpose of science education is to educate people with scientific literacy and help them understand how scientists discover theories. Thus, people can discover the problems they encounter in their daily lives and follow a scientific process by formulating hypotheses relevant to the problem [Liang, 2002 cited in 4]. The current science course curriculum in Turkey, which was started to be implemented in the 2005-2006 academic year, aims to educate people by equipping them with not only science but also technological literacy. In this sense, the curriculum highlights STSE relationships, scientific process skills (SPS), and attitudes and values (AV) [5]. Following the changes in science and technology courses implemented in 2004, Primary Education and Education Law no 6287 was enacted on March 30, 2012, which extended the compulsory education period up to 12 years. Moreover, many important changes took place in primary education as well as other curricula [6]. SPS remained important in middle education curricula as well. The eight-year compulsory primary education was transformed into a stage-based structure, which each of the two stages covering four years, followed by another four years for completion of one's education. In Turkey, this 4+4+4 education system led to the Science and Technology course, which was created in 2005 [6], being renamed Physical Sciences. However, no change was made in the scope of the course, which was based on objectives and learner centeredness. As was adopted in the previous curriculum, a strategy based on learner centeredness, active participation, construction of knowledge in mind, research and inquiry was employed, in which the teacher acts as a mentor and guide. The learner is the researcher, inquirer, and an individual who acquires information through the discussion and sourcing of information. It is important for students to acquire SPS for enabling students to solve problems, think critically, make decisions, find answers, and satisfy their curiosity. Furthermore, SPS are very important for meaningful learning because learning is a lifelong process and individuals should learn and interpret the events they experience [7].

SPS have been defined in a variety of ways in the literature. Çepni, Ayas, Johnson, and Turgut [8] defined SPS as basic skills that facilitate learning for students in sciences, help them acquire research methods and techniques, allow active participation, improve the sense of responsibility for their learning, and raise the permanency of learning. Şahin-Pekmez [9] defined SPS as basic skills that facilitate learning, teach exploration methods, make students active, develop their responsibilities, and help them understand laboratory studies. Hazır and Türkmen [10] described SPS as a lifelong learning process that lays the foundation of analytical thinking and is used to construct knowledge through learning by doing and experimenting with principles as well as problem solving. Lind (1998) defined them as the thinking skills we use when we are constructing knowledge, thinking over problems, and formulating results [Cited in 11].

Bağcı-Kılıç [12] categorized 12 skills into two categories: basic skills and combined skills. These skills were explained in MoNET's curriculum under three titles. Tan and Temiz [13] identified 13 types of SPS expressed in previous studies. Generally, these skills were expressed with similar names in various resources with different types of groupings [Gabel, 1992; Rezba et al., 1995; Smith, 1995; Valentino, 2000; Lancour, 2005; A.A.A.S., 1998 cited in 14; Marshall, 1990; Yeany, Yap & Padilla, 1986 cited in 15, 8]. These skills are as follows: "Basic Skills: Observation, Measurement, Classification, Recording data, the Relationship between numbers and space. Causal Skills: Prediction, Identifying variables, Interpreting data, and Deduction. Experimental Skills: Formulating hypotheses, Using data and Creating model, Making decisions, Changing and Controlling variables, and Experimenting [8, 17].

In order to enhance students' SPS, it is important for the physics, chemistry, biology, and science teachers who educate these students to acquire these skills themselves. Physics, chemistry, and biology are the most appropriate courses in which students can experience the scientific process during middle education whereas these courses are science courses for primary education [12]. In the first stage of primary school education, primary school teachers play an important role in laying the foundation for science courses. As a result of changes in curricula, primary school teachers are responsible for administering science courses to third grade students, which means they must possess the knowledge and skills related to science concepts. Teachers' SPS are influential in the acquisition of these skills by students [16]. In this sense, this study dwells on a comparative analysis of the identification of SPS among students from two departments in the Faculty of Education: primary school teaching and physical sciences.

2. Materials and Methods

The survey method was employed in this study. Çepni [17] defined a field survey as a type of research focusing on the revelation of the current situation. In such studies, the questions "what is the current status of the event or problem?" and "where are we?" are often addressed. The purpose of this method is to define the nature and characteristics of objects, communities, organizations, and events. As it is necessary to acquire a significant amount of information about any event in order to define it, studies employing the survey method cover much data [18].

2.1. Sample

The sample of the current study covers 95 pre-service science teachers in their third year and 95 pre-service primary school teachers also in their third year of study at the Faculty of Education in Recep Tayyip Erdoğan University in Turkey.

2.2. Data Collection Tools and Data Analysis

The Scientific Process Skills test, the 24-question data collection tool developed by Tümer [19] used in this study, has a reliability value of KR-20=0.76. Regarding the validity of this data collection tool, views from three experts were gathered to evaluate which SPS were measured by the questions on the test. Then, based on consensus, they were implemented on the sample. Some sample questions from the test are as follows:

Sample Question 1.

The melting and boiling points of the substances x, y, and z are given in the table below.

Substance	Melting point °C	Boiling point °C
X	30	160
Y	-10	50
Z	15	210

According to the table, which substances are in the liquid state when the temperature is 25°C under the same conditions?

a Only x b. y and z
c. x and z d. x, y, and z

Sample Question 2.

A wooden spoon and a metal spoon are put on a porcelain plate and kept at room temperature for a long time.

When the plate and spoons are touched by hand, the metal spoon feels colder. What is the reason for this? Choose the correct answer.

a. The porcelain plate and the wooden spoon have higher heat conductivity compared to the metal spoon.
b. The metal spoon has the highest heat conductivity.
c. The metal spoon has the lowest heat conductivity.
d. The metal spoon is colder.

Sample Question 3.

1. Increasing the number of bulbs
2. Increasing the number of batteries
3. Decreasing the number of bulbs

Which of these actions increase the brightness of the bulbs in a simple electric circuit?

a. 1 and 2 b. Only 2
c. 2 and 3 d. Only 3

The students were asked to mark the correct answer for each question on the test. They were also asked to specify which SPS the question measured. When analyzing students' answers, the correct answers given to each question and the SPS measured by that answer were tabulated with their frequencies. As nearly 100 students (i.e., 95) responded to the test items, no percentage calculations are given in the tables.

3. Findings

The answers given to scientific process skills test by pre-service primary teachers and science teachers are given in the following tables.

Table 1. Frequencies of Answers to SPS Test Given by Pre-Service Primary School Teachers

Question No.	Correct (f)	Incorrect (f)	Blank(f)
1	92	1	2
2	67	27	1
3	73	14	8
4	77	2	16
5	92	-	3
6	87	1	7
7	69	7	19
8	78	7	10
9	75	5	15
10	4	75	16
11	71	10	14
12	83	1	11
13	74	5	16
14	57	12	26
15	64	6	25
16	75	3	17
17	35	13	47
18	47	21	27
19	34	58	3
20	65	12	18
21	52	25	18
22	69	8	18
23	19	53	23
24	22	32	41

Table 1 indicates that pre-service primary school teachers mostly gave correct answers to questions 1 through 9 (92, 67, 73, 77, 92, 87, 69, 78, and 75 students, respectively), 11 through 16 (71, 83, 74, 57, 64, and 75 students), and 20 through 22 (65, 52, and 69 students). Meanwhile, questions 10 (75 students), 19 (58 students), and 23 (53 students) were answered incorrectly. Finally, 47 students did not answer question 17 while 41 did not answer question 24.

Table 2. Answers to Identifying the Skills on the SPS Test and Frequencies Given by Pre-Service Primary School Teachers

Question No.	The Correct SPS and Frequencies	Other Students' Answers and Frequencies		
1	Prediction: 4	Observation: 55 Deduction: 14	Other skills: 8	Blank: 14
2	The relationship between numbers and space: 49	Creating model: 26	Other skills: 9	Blank: 11
3	Observation: 41	Experimenting: 16	Other skills: 29	Blank: 9
4	Formulating hypotheses +experimenting: 46	Classifying: 11 Measuring: 7	Other skills: 18	Blank: 13
5	Classifying: 61	Interpreting data: 9	Other skills: 16	Blank: 9
6	Measuring: 18	Experimenting: 33 Interpreting data: 28	Other skills:	Blank: 9
7	Recording data: 1	Experimenting: 18 Observation: 23 Changing or controlling the variables: 6	Other skills: 7	Blank: 9
8	Deduction: 13	Experimenting: 44	Other skills: 28	Blank: 10
9	Deduction: 5	Experimenting: 35 Measuring: 26	Other skills: 10	Blank: 19
10	Changing or controlling the variables: 44	Identifying variable: 37	Other skills: 5	Blank: 9
11	Interpreting data+ Deduction: 45	Observation: 19 Measuring: 10	Other skills: 7	Blank: 14
12	Interpreting data + Deduction: 40	Observation: 12	Other skills: 20	Blank: 23
13	Prediction: 16	Observation: 30 Deduction: 9	Other skills: 27	Blank: 13
14	Interpreting data + Deduction: 39	Classifying: 9 Experimenting: 5	Other skills: 11	Blank: 31
15	Classifying: 51	Interpreting data: 8	Other skills: 6	Blank: 30
16	Experimenting: 28	Observation: 20 Prediction: 12 Formulating hypotheses: 9	Other skills: 13	Blank: 13
17	Changing or controlling the variables: 47	Experimenting: 24	Other skills: 5	Blank: 19
18	Deduction: 32	Experimenting: 26	Other skills: 12	Blank: 25
19	Measuring: 1	Observation: 58 Prediction: 12 The relationship between numbers and space: 10	Other skills: 6	Blank: 8
20	Identifying variable: 14	Changing or controlling the variables: 48 Experimenting: 10	Other skills: 9	Blank: 14
21	Identifying variable: 26	Observation: 32 Deduction: 10	Other skills: 13	Blank: 14
22	Experimenting: 64	Observation: 8 Prediction: 4	Other skills: 3	Blank: 16
23	Interpreting data+ Creating model: 43	Recording data: 13 Deduction: 10	Other skills: 14	Blank: 15
24	Formulating hypotheses: 24	Experimenting: 18 Interpreting data: 13	Other skills:	Blank: 21

The second section of the SPS test asked students to specify which skills are measured through the questions in the test. Table 2 shows that questions 1, 6 through 9, 13, 19, and 20 were generally answered incorrectly. The first question involves prediction skill. However, only 4 students gave the answer of prediction; meanwhile, 55 students mentioned observation while 14 said deduction and another 8 stated other skills. In addition, 14 students did not answer the question. Question 6 involves measuring skills, which 18 students correctly identified; however, 33 students stated experimenting, 28 mentioned interpreting data, and 9 students did not answer. Question 7 involves skills of recording data.

Only 1 student gave the correct answer; 23 students mentioned observation, 18 stated experimenting 7 gave responses involving other skills, and 9 students did not answer. Question 8 involves deduction skills, which 13 students correctly identified; 44 students mentioned interpreting data, 28 students gave responses involving other skills, and 10 students did not answer the question. Question 9 involves the same skill as question 8. Five students correctly mentioned deduction, 35 students stated interpreting data, 26 students denoted measuring, 10 students gave responses involving other types of skills, and 19 students did not answer the question. Question 13 involves prediction skills. Thirty students stated observation, 16 students mentioned prediction, 9 students denoted deduction, 27 students gave answers involving other types of skills, and 13 students did not answer the question. Question 19 involves measuring skills, which 1 student correctly identified; 58 mentioned observation, 12 students mentioned prediction, 10 students mentioned the relationship between numbers and space, 6 students gave responses involving other types of skills, and 8 students did not answer the question. Question 20 involves identifying variables; 48 students gave the response of changing and controlling variables, 10 stated experimenting, and 9 students gave responses involving other types of skills while 14 students did not answer the question.

Table 3. Frequencies of the Answers to the SPS Test Given by Pre-Service Science Teachers

Question No	Correct (f)	Incorrect (f)	Blank (f)
1	91	4	-
2	65	29	1
3	89	5	1
4	78	12	5
5	94	-	1
6	88	5	2
7	66	19	10
8	75	13	7
9	84	6	5
10	68	15	12
11	84	7	4
12	90	3	2
13	78	14	3
14	75	13	7
15	71	8	16
16	83	7	5
17	55	25	15
18	67	14	14
19	40	47	8
20	60	23	9
21	49	38	8
22	80	11	4
23	51	33	11
24	40	46	9

Table 3 indicates that most of the pre-service science teachers answered the questions correctly, although questions 19 and 24 were answered incorrectly (by 47 and 46 people, respectively) and questions 10, 15, 17, and 18 were not answered by 12, 16, 15, and 14 people respectively.

Table 4. Answers to Identify the Skills on the SPS Test and Frequencies Given by Pre-Service Science Teachers

Question no.	The correct SPS and frequencies	Other Students' answers and frequencies		
1	Prediction: 19	Observation:48 Deduction:14	Other skills :17	Blank:11
2	The relationship between numbers and space: 47	Creating model: 20	Other skills:21	Blank:7
3	Observation: 33	Experimenting:28	Other skills: 23	Blank: 11
4	Formulating hypotheses+ Experimenting: 51	Changing variable: 9 Deduction: 8	Other skills:13	Blank: 14
5	Classifying: 48	Observation:12 Experimenting:12	Other skills:12	Blank: 11
6	Measuring: 16	Using data:21	Other skills:40	Blank: 18
7	Recording data: -	Experimenting:22 Observation:21 Prediction:18	Other skills:8	Blank: 26
8	Deduction:24	Experimenting:24	Other skills:28	Blank:19
9	Interpreting data+ Deduction:49	Experimenting: 9	Other skills:16	Blank:21
10	Changing and controlling variable: 44	Identifying variable: 37	Other skills:5	Blank: 9
11	Interpreting data+ Deduction: 46	Observation:17	Other skills:14	Blank: 18
12	Interpreting data+ Deduction:35	Observation: 20	Other skills:17	Blank: 23
13	Prediction: 23	Observation: 25	Other skills:32	Blank:15
14	Interpreting data+ Deduction:46	Measuring:11	Other skills:15	Blank: 23
15	Classifying: 39	Prediction:8	Other skills:12	Blank:36
16	Experimenting: 36	Observation:22 Formulating hypotheses:14	Other skills:9	Blank:14
17	Changing and controlling variable:28	Experimenting: 28	Other skills:4	Blank:35
18	Deduction:18	Observation: 19	Other skills:24	Blank:34
19	Measuring+ Observation:52	Prediction:10	Other skills:13	Blank:20
20	Identifying variable: 35	Experimenting:15	Other skills:14	Blank:31
21	Identifying variable: 12	Prediction:18 Interpreting data:13	Other skills:24	Blank:28
22	Experimenting: 43	Observation:17	Other skills:18	Blank:17
23	Interpreting data+Creating model: 30	Deduction:23	Other skills:22	Blank:20
24	Formulating hypotheses: 8	Experimenting:25 Observation:20	Other skills:20	Blank:22

According to Table 4, most students gave incorrect responses to questions 1, 6, 7, 13, 18, 21 and 24 in terms of the skills measured by the question. Question 1 involves prediction skills; however, only 19 students gave the correct response. Meanwhile, 48 students stated observation, 14 students suggested deduction, 17 students gave responses involving other types of skills, and 11 students did not answer the question. Question 6 involves measuring skills, which 16 students correctly identified; 21 stated using data, 40 mentioned other types of skills, and 18 did not answer the question. Question 7 involves the skill of recording data; 21 students gave the response of observation, 22 stated experimenting, 18 mentioned prediction, 8 gave answers involving other types of skills, and 26 did not answer the question. Question 13 involves prediction skills, which 23 students correctly identified; 25 stated observation, 32 mentioned other types of skills, and 15 students did not answer the question. Question 18 involves deduction skills; 18 identified this skill correctly whereas 19 stated observation, 24 mentioned other types of skills, and 34 did not answer the question. Question 21 involves the skill of identifying variables, which 12 students identified; 18 stated prediction, 13 mentioned interpreting data, 24 gave responses involving other types of skills, and 28 did not answer the question. Question 24 involves the skill of formulating hypotheses, which 8 students identified; 25 stated experimenting, 20 stated observation, 20 mentioned other types of skills, and 22 did not answer the question.

4. Discussion and Conclusions

Pre-service primary school teachers generally gave many incorrect responses on the SPS test to questions involving the skills of changing and controlling variables, deduction, and measuring observations (questions 10, 19, and 23). Nearly half of the students did not answer questions 17 or 24, which involve changing and controlling variables and formulating hypotheses (see Table 1). Pre-service science teachers gave many incorrect answers to questions 19 and 24, which involve measuring observations and formulating hypotheses. Only a few students did not answer questions 10, 15, 17, or 18, which involve changing and controlling variables, classifying, and deduction (see Table 3). These results indicate that pre-service science teachers were more successful than pre-service primary school teachers in responding to the SPS questions. Table 3 shows the number of correct answers given by pre-service science teachers and Table 1 shows the number of correct answers given by pre-service primary school teachers. Pre-service science teachers had more correct answers than pre-service primary school teachers, thereby supporting the results. Taking into consideration that pre-service science teachers receive more intense science education in terms of both content and quantity as well as in both high school and university, this result is not surprising. However, as a result of the changes in curricula, pre-service primary school teachers teach science courses to the third grade, which makes it necessary to better equip these pre-service teachers with content and skills involving science concepts. The fact that 15 or more pre-service primary school teachers did not answer questions 1, 9, 11, 12, 14, 15, 17, 18, and 20 through 24 (see Table 2) can be considered an indicator of such a necessity. A similar situation emerged for the pre-service science teachers, who left even more questions unanswered (questions 4, 6 through 9, and 11 through 24) than the pre-service primary school teachers, as evident in Table 4.

Pre-service primary school teachers identified observation and deduction skills for questions 1 and 13, which involve prediction skills. They also identified experimenting, interpreting data, observation, and prediction for questions 6 and 19, which involve measuring skills; for question 7, which involves the relationship between number and space and recording data, they stated experimenting, observation, and changing and controlling variables. For questions 8 and 9 involving deduction skills, they mostly stated experimenting, interpreting data, and measuring. They identified changing and controlling variables and experimenting skills for question 20, which involves the skill of identifying variables (see Table 2). Pre-service science teachers stated observation and deduction skills for questions 1 and 13, which involve prediction skills. For question 6, involving measuring skills, they stated other types of skills. They identified experimenting, observation, and prediction skills for question 7, involving the skill of recording data. For question 18, involving deduction skills, they responded with observation and other types of skills. They mostly stated prediction and interpreting data and other types of skills for question 21, involving the skill of identifying variables. For question 24, involving the skill of formulating hypotheses, they mostly stated experimenting and observation skills (see Table 4).

Based on these results, it can be concluded that pre-service teachers confuse prediction skills (questions 1 and 13) with observation and deduction skills; the relationship between number and space (question 2) with creating models; observation skills (questions 3 and 16) with experimenting skills; measuring skills (questions 6 and 19) with experimenting, interpreting data, observation, and prediction skills; the skill of recording data (question 7) with experimenting and observation skills; deduction skills (questions 8, 9, and 18) with the skills of experimenting and interpreting data; the skill of changing and controlling variables (questions 10, 20, and 21) with identifying variables, observation and deduction skills; and the skill of formulating hypotheses (question 24) with experimenting and interpreting data skills, which they use interchangeably (see Table 2). This is a common result for many questions. It indicates that pre-service teachers cannot distinguish SPS and the differences between them. Pre-service teachers probably confused the relationship between number and space in three dimensions with the skill of creating models. The reason for such confusion might be that they did not comprehend the concept of "variable" thoroughly. For those questions with activity content, pre-service teachers instead stated experimenting skills instead of measuring, recording data, deduction, formulating hypotheses, and observation skills. This suggests that they cannot comprehend this high-level skill and use the term experimenting in their explanation as a kind of generalization. Similarly, pre-service science teachers confuse prediction skills (questions 1 and 13) with observation and deduction skills, the relationship between number and space (question 2) with creating models, observation skills (questions 3 and 16) with experimenting, the skill of recording data (question 7) with experimenting and observation, deduction skills (questions 8 and 18) with experimenting and observation skills, the skill of changing and controlling variables (questions 10 and 17) with the skill of identifying variables and experimenting, and the skill of formulating hypotheses (question 24) with experimenting and observations, using them interchangeably (see Table 4). Pre-service primary school teachers might have given similar responses as the pre-service science teachers because of the positive reflection of the activities they carried out for two terms in the Science Laboratory Practices courses (I-II) in their second year of undergraduate education.

All in all, pre-service science teachers answered more questions correctly in the first section of the SPS test and were more successful than pre-service primary school teachers. In addition, more pre-service primary school teachers did not answer the questions in this section than pre-service science teachers. Considering the second section of the test, pre-service teachers from both departments gave similar responses when identifying the skills. In other words, no distinct difference emerged in their answers. Previous studies have suggested that students may have high academic achievements but lower scientific process skills [20]. In addition, they might use many skills interchangeably. In this study, pre-service teachers from both groups used high-level experimenting skills, which covered the majority of other skills in many questions, for other skills (measuring, recording data, deduction, formulating hypotheses, and observation skills). The reason may be that experimental process skills are more complicated, abstract, and advanced skills [21]. Furthermore, they confused the skills of changing and controlling variables with the skill of identifying variables. According to Şimşek, [22], Anagün and Yaşar [23], Şimşekli and Çalış [24], Ateş [25], and Ateş and Bahar [26], pre-service primary school teachers have not shown the expected improvement in identifying experiment variables. Hughes and Wade [27] found that children can change two or more variables simultaneously until the age of 13 to 15. Therefore, they emphasized the importance of students acquiring the skills of changing and controlling variables during their primary school education. However, some deficiencies exist in the education given to teachers who will introduce these skills to the class [16]. In order for students to effectively discuss their ideas as well as advocate and enhance them within groups, teacher training is as important as the necessary social skills [Myers, Washburn & Dyer, 2004 cited in 11].

5. Recommendations

An alteration was made to the science curriculum in Turkey in 2013. Accordingly, third-grade students now receive a science course as well. Therefore, it is more important for pre-service primary school teachers who will administer this course to enhance their knowledge and skills regarding science concepts. During the undergraduate period, pre-service teachers should learn the concepts regarding theoretical science courses better. Moreover, contests, projects, and posters should be used to cover scientific process skills. Existing studies have indicated that SPS can be improved through cooperative learning, group work, trips, and observations by associating them with daily life and assigning projects [28, 29, 30]. Şimşekli and Çalış [24] conducted a study to examine pre-service primary school teachers' SPS. They observed that some of these teachers could not answer the questions correctly, even at the end of the semester. At the end of their study, they suggested that these skills be enhanced through a variety of practices and in many courses. Such practices are important for not only pre-service primary school teachers, but also pre-service science teachers in order to eliminate their deficiencies related to SPS. The skills that these pre-service teachers often confuse should be prioritized in these activities in order to provide opportunities to eliminate their deficiencies. The laboratories in which experiments suitable for these skills are carried out play an important role in the acquisition of SPS as well [Roth & Roychoudhury, 1993; Knabb & Misquith, 2006 cited in 20].

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