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| Research Article / Araştırma Makalesi |

Investigation of Students' Hypothesis Skills In Chemistry Laboratory Applications

Kimya Laboratuvarı Uygulamalarında Öğrencilerin Hipotez Kurma Becerilerinin İncelenmesi

Şule Yaz[1], Zekeriya Yerlikaya[2]

Keywords

1. Establishing hypothesis
2. Hypothesis building skills
3. Llaboratory activities,
4. science education.
5. Scientific process skills

Anahtar Kelimeler

1. Bilimsel süreç becerileri.
2. Hipotez, hipotezi kurma becerileri.
3. Laboratuvar etkinlikleri
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Abstract

Purpose: This study aimed to determine the skill level of hypothesis gained by the students as a result of the applications made with the activities designed based on Scientific Process Skills.

Design/Methodology/Approach: In this study, in the context of constructivist learning approach; A laboratory training material which has been developed by Yaz (2018), consisting of 10 activities, which includes hypothesis-based experimental technique applications, enriched in terms of scientific process skills, has been used in the General Chemistry Laboratory-I course in the Faculty of Education Science Education program.

This research was carried out with 31 students studying in the first grade of the Science Teaching Department in the Faculty of Education. General Chemistry Laboratory I courses were conducted for 10 weeks with activities developed based on scientific process skills. This research is a descriptive research type and designed according to the qualitative research approach. After performing the activities, content analysis was conducted on the student reports, and the students' ability to form hypotheses were determined.

Findings: As a result of the content analysis conducted on the students' experimental results reports, it was concluded that a significant number of students were able to construct at least one or more researchable and testable hypotheses about the subject of the experiment.

Highlights: It was concluded that a significant part of the hypotheses established could be investigated and tested, and no significant difficulties were encountered during the applications. It was determined that the rate of students who could establish testable and meaningful hypotheses (80%) was higher than the rate of students who could not establish such hypotheses (20%). In addition, it can be said that such activities designed for the acquisition of process skills can contribute positively to both the acquisition of adequate process skills to the students and the permanence of these skills.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, bilimsel süreç becerilerine dayalı olarak tasarlanan etkinliklerle yapılan uygulamalar neticesinde öğrencilerin kazandığı hipotez kurma beceri düzeylerini tespit etmektir.

Materyal ve Yöntem: Bu çalışmada, yapılandırmacı öğrenme yaklaşımı kapsamında; öğrenciyi aktif kılan, bilimsel süreç becerileri dikkate alınarak hazırlanan, hipoteze dayalı deney tekniği uygulamalarını içeren, 10 etkinlikten oluşan ve Yaz (2018) tarafından geliştirilen bir laboratuvar eğitim materyali Eğitim Fakültesi Fen Eğitimi Anabilim Dalı programında yer alan Genel Kimya Laboratuvarı I dersinde kullanılmıştır. Bu araştırma, Eğitim Fakültesinde Fen Bilgisi Öğretmenliği bölümü 1. sınıfta öğrenim gören 31 öğrenci ile yürütülmüştür. Genel Kimya Laboratuvarı I dersleri, 10 hafta boyunca, bilimsel süreç becerilerine dayalı olarak geliştirilen etkinliklerle yürütülmüştür. Bu araştırma, betimsel desene sahip bir araştırma türüdür ve nitel araştırma yaklaşımına uygun olarak tasarlanmıştır. Etkinliklerden gerçekleştirildikten sonra, öğrenci raporları üzerinde içerik analizi yapılmış ve öğrencilerin hipotez kurma becerileri tespit edilmiştir.

Bulgular: Gerçekleştirilen etkinlikler sonrasında, öğrenci deney sonuç raporları üzerinde yapılan içerik analizleri neticesinde, önemli sayıda öğrencinin deneyin konusu hakkında en az bir veya daha fazla araştırılabilir ve test edilebilir hipotez oluşturabildiği sonucuna varılmıştır.

Önemli Vurgular: Oluşturulan hipotezlerin önemli bir kısmının araştırılıp test edilebildiği ve uygulamalar sırasında önemli bir güçlükle karşılaşılmadığı sonucuna varılmıştır. Test edilebilir ve anlamlı hipotezler kurabilen öğrencilerin oranının (%80), bu tür hipotezleri kuramayanların oranından (%20) daha yüksek olduğu belirlenmiştir. Ayrıca süreç becerilerinin kazanılmasına yönelik tasarlanan bu tür etkinliklerin hem öğrencilere yeterli süreç becerilerinin kazanılmasına hem de bu becerilerin kalıcılığına olumlu katkı sağlayabileceği söylenebilir.

[1]2 **Corresponded Author,** Kastamonu University, Faculty of Education, department of Mathematics and Science Education, Kastamonu, TURKEY; https://orcid.org/0000-0003-3659-2100

[2]1 Kastamonu Directorate of National Education, Kastamonu Directorate of National Education, Kastamonu, TURKEY; https://orcid.org/0000-0002-6938-3535

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INTRODUCTION

Many curricula and standards prepared in the field of science emphasize that students should learn both scientific knowledge and skills related to the construction of this knowledge within the scope of the constructivist approach. One way to achieve this goal is to use inquiry-based learning activities that include acquisitions related to science process skills (Stender, A. et al. 2018). When evaluated in terms of both basic skills and experimental (high-level) skills, Scientific Process Skills (SPS) is a unique skill that can be gained efficiently and easily at both levels in a practical way, when appropriate activities and teaching-learning strategies are designed in science lessons (Padilla, 1990; Winarti, A. et al., 2019; García-Carmona, A., 2020).

In science education, the applications of inquiry-oriented experimental techniques give teachers and students the opportunity to investigate their environment (Alouf & Bentley, 2003). With this technique, the student designs the necessary experiments to test the accuracy of a hypothesis about a problem under the supervision of a teacher. In addition, he sets up the relevant experimental setups, records his observations and data by doing experiments, interprets the results obtained to decide whether this hypothesis is true or false, accepts the results if the hypothesis he has established is true, rejects those results if it is wrong, the student creates a new hypothesis and tests. A well-designed student-centered laboratory activity can provide students with the experiences necessary to develop SPS and distinguish conceptual structure. In addition, in such approaches, a more effective and accurate concept teaching can be provided by designing and applying experiments that include examples from daily life.

Chatterjee et al. (2009) revealed that students prefer the research and inquiry-based experimental technique and have gained more knowledge and skills with this technique. In the experimental technique based on research and inquiry, students are given a problem that they need to solve and sometimes the necessary tools and explanatory materials. Under the teacher's guidance, the students themselves design and conduct experiments, collect relevant data, and evaluate results. The teacher guides the students with questions when necessary to make it easier for them to reach a conclusion and/or deepen the subject.

Laboratory methods and applications are of great importance in science education, which includes theoretical and practical education. Hofstein & Lunetta (2004) stated that laboratories are in a central position in science education. Without laboratory applications, it is inconceivable that the science course can be successful. Due to the nature of the science course, learning in science education courses doesn't only happen in school classrooms; people may also experience learning outside of the formal classroom setting. Other than classroom learning, learning also takes place both in laboratories set in schools and in environments out of schools named as "out-of-school learning". Parallel to the developments in science and technology, alternative out-of-school learning environments (e.g., science cafés, virtual reality (VR) Technologies, home-lab activities) that further students' science learning have emerged in recent decades. In general, student-centered practical studies carried out in different learning environments can contribute to the increase of students' motivation and self-confidence, and ultimately to the realization of permanent and meaningful learning (Şen Et al., 2021; Tal, 2012; Kılıç & Aydın, 2018; Rennie, 2014; Yıldırım, 2018)

(Kılıç & Aydın, 2018). It was stated that as a result of the learning by doing and experiencing approach, knowledge would be more permanent, and because of this, the importance of laboratory used and applied studies in science education is becoming widespread day by day (Toprak, 2011).

In a study conducted by Şimşir et al. (2018), some activities for the General Chemistry-II laboratory course were designed and developed based on the SPS and the constructivist laboratory approach. It has been reported that these activities reveal a significant difference in the academic achievement of students.

In a study conducted by Ünal (2018), various activities based on inquiry and social network support were carried out for prospective teachers studying in the first grade in General Chemistry Laboratory II course. According to the results of the study, it was revealed that students' perceptions of scientific process skills and their academic achievement changed in a positive and meaningful way.

In the science education program in Turkey, the skills specific to the field of science education have been indicated as one of the SPS areas (MEB, 2018). The field of SPS includes the skills scientists use during their work, such as observing, classifying, measuring, predicting, expressing, recording data, forming and testing hypotheses, changing and controlling variables, conducting experiments, interpreting data, identifying by doing, and creating models. With the help of the scientific process skills planned to be acquired by this program, it was stated that various achievements, which are one of the important goals of science education, can be achieved to generate solutions to the problems encountered in daily life.

This study aimed to determine the hypothesis-building skill levels that students gain as a result of the applications made with the activities designed based on scientific process skills. In this study, within the scope of the General Chemistry Laboratory I course, which consists of 10 activities, a laboratory education material suitable for the constructivist learning approach, which makes the student active, taking into account SPS and including hypothesis-based experimental technique applications, was used (Yaz, 2018).

METHOD/MATERIALS

This section includes the model of the study, study group, data collection tool, and data analysis sections.

Research Design and Methodology

This research was designed in accordance with a qualitative research approach and had a descriptive design. The purpose of descriptive analysis is to make the raw data collected can be easily understood by researchers. The data collected in the descriptive analysis are classified, summarized, and interpreted according to previously prepared themes (Altunışık et al., 2001). In this study, content analysis was made on student reports, and determinations were made regarding hypothesis-building skills.

In this study, a laboratory education material consisting of a constructivist laboratory approach and SPS-based 10 activities and containing instructions were developed for the first-year science education students to apply in the General Chemistry Laboratory I course. The prepared material was examined by two experts, and the material was finalized in line with their opinions. After implementing the activities, as a result of the content analysis made on the student reports, the hypothesis-building skills of the students were determined. The stages in this research are given below:

- The SPS, which is aimed to be acquired, was analyzed by analyzing the content for each activity, and skills were determined.
- At the end of each activity, the students were guided with appropriate sentences and explanations to make research and observations on the next activity topic.
- The experiments are designed in accordance with the experimental technique of establishing and testing hypotheses, which are based on inquiry and will provide as many process skills as possible. In the content of the designed activity, students were encouraged to make at least one hypothesis sentence by giving sample hypothesis sentences.
- Significant and testable hypotheses were determined by conducting a content analysis on student reports.

Working group

This research was conducted at an education faculty in Turkey. The research group was composed of 31 first-year students studying in the Department of Science Education in the 2017-2018 academic year.

Implementation Process and Designed Activities

The experiments designed according to the theoretical course, General Chemistry-I, were carried out in accordance with the content of the course and in communication with the instructors who gave the course. The activities developed were applied to the students studying in the first year of science teaching for 10 weeks, two hours a week, in the spring semester of the 2017-2018 academic year.The names of the activities designed and implemented are given below (Summer, 2018):

Experiment 1: Boiling, Evaporation, Condensation, and Distillation in Liquids.

Experiment 2: Physical and Chemical Changes in Substances.

Experiment 3: Hydrogen Gas and Combustion Reaction.

Experiment 4: Stoichiometry.

Experiment 5: Investigation of Acids and Bases: Neutralization Reactions.

Experiment 6: Determination of Heat-Temperature Difference of Different Materials with Equal Mass**.**

Experiment 7: Determining the Amount of Energy in Foods**.**

Experiment 8: Solubility and Inter-Particle Interactions in Solutions**.**

Experiment 9: Interaction Between Particles and Surface Tension in Liquids**.**

Experiment 10: Hess's Law

The SPS, which is aimed to be acquired in science education, has been classified into two groups: basic processes and experimental processes (Martin, 1994; Martin, 1997; Yerlikaya, 2006). The explanations about these skills and the abbreviations used for each skill in this study are shown in Tables 1 and 2. Table 3 shows which skills are aimed to be acquired with the designed activities. . A section from the designed experiment sample was shown in figure 1.

Table 1. SPS-1: Basic processes.

Code	Sps-1: Basic Processes	Descriptions
SPS -1.1	Observation	Science begins with observation and builds on previous knowledge (Ayas, 1994). It is the determination of the properties of an object or event using sense organs (Özaydın, 2010).
SPS -1.2	Classification	Classification is the grouping of events, opinions, and objects by certain characteristics. It is a skill of using the events and generalizations used in scientific subjects and necessary to form the concepts (Silay & Çelik, 2013; Yerlikaya, 2006).
SPS -1.3	Measuring, using space and time relationships	Expressing the characteristics of materials numerically. Length, volume, weight, temperature, and time are five variables students use (Silay & Çelik, 2013; Yerlikaya, 2006).
SPS -1.4	Prediction	Making a prediction about situations and events (Harlen & Jelly, 1989).
SPS -1.5	Inferring	Making predictions and drawing conclusions based on the available information (Martin, 1997).
SPS -1.6	Communication (Expression)	Expressing opinions and thoughts about events and situations when communicating with other people (Yerlikaya, 2006).

Table 2. SPS -2: Experimental processes

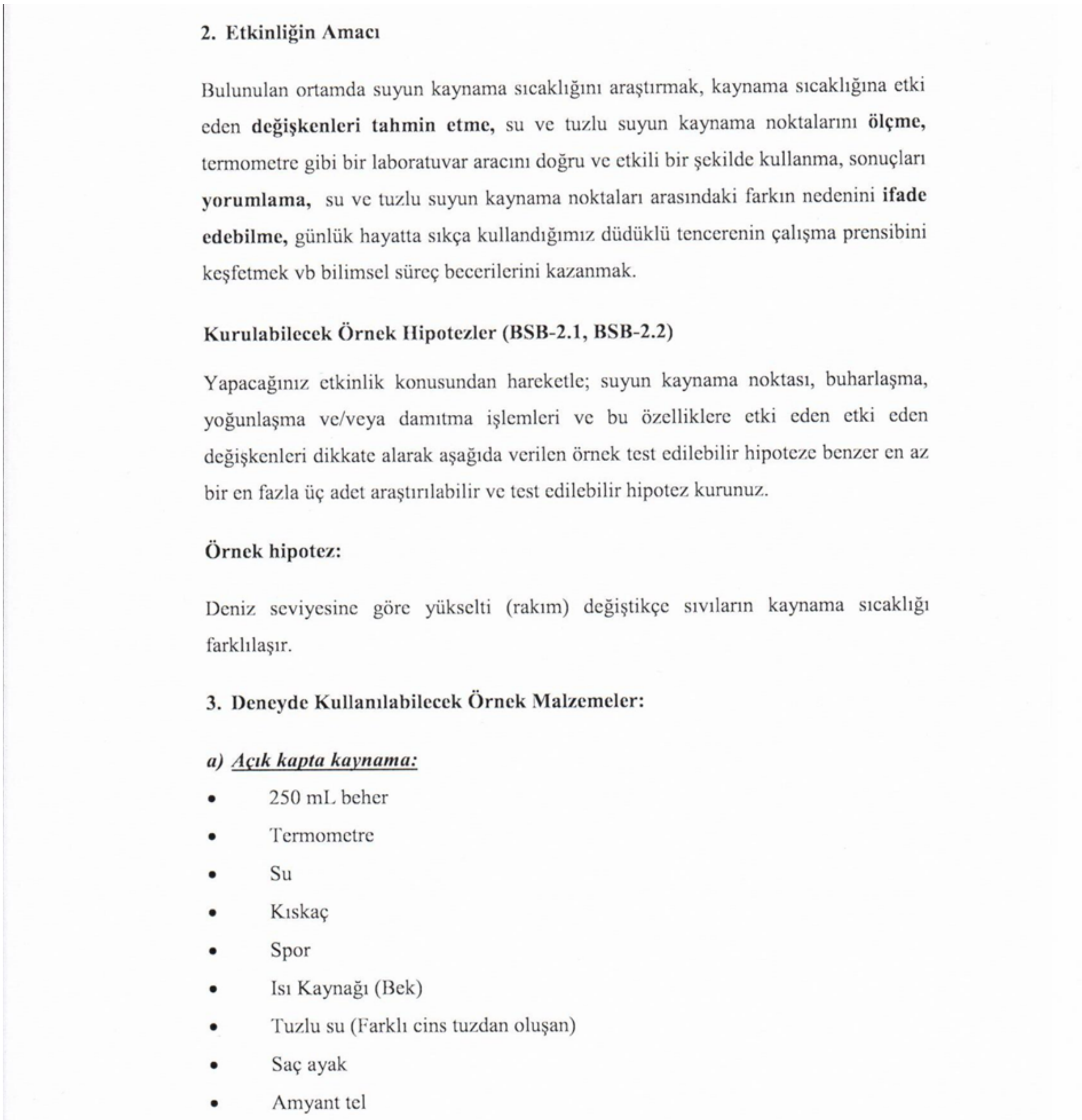
Code	Sps -2: Experimental Processes	Descriptions
SPS -2.1	Hypothesis building and Testing the Hypothesis	Hypotheses are propositions formed based on variables to construct laws and theories (Ayas et al., 1997).
SPS -2.2	Defining and controlling variables	Defining variables and revealing the effect of another variable on a variable (Yerlikaya, 2006).
SPS -2.3	Interpreting the data	It is a comprehensive process that includes making sense of data obtained through experimental studies (Ayas et al., 1997).
SPS -2.4	Defining operationally	It is the process of measuring variables indirectly in scientific studies where variables cannot be measured directly (Yerlikaya, 2006).
SPS -2.5	Organizing and conducting experiments	It is a process that includes scientific skills such as designing and implementing the experiment, making observations, changing and controlling variables, obtaining and interpreting data during this application process (Yerlikaya, 2006).
SPS -2.6	Making a model	It is the process of making assets and events concrete with graphics, figures, or multiple visual materials (Martin, 1994).

The experiments designed were created based on the constructivist laboratory approach and SPS to ensure students are at the center of learning. In each designed experiment, the rules that students must obey regarding the safety precautions and the use of the laboratory environment were explained to the students separately, and their attention was drawn to this issue. In the experiment sheets given to the students, the guiding sentences about the process skills acquisition are shown in bold letters (without SPS number) on the text. Each activity was analyzed by content analysis, and each SPS aimed to be gained determined separately. The scientific process skills aimed to be acquired in the applied activities are shown in Table 3.

Table 3. Scientific process skills aimed to be acquired by students through the activities developed

Activity Number	Scientific process skills												Total SPS targeted to be gained with the activities designed
	Basic processes						Experimental processes						
	SPS 1.1	SPS 1.2	SPS 1.3	SPS 1.4	SPS 1.5	SPS 1.6	SPS 2.1	SPS 2.2	SPS 2.3	SPS 2.4	SPS 2.5	SPS 2.6	
1	+	+	+	+	+	+	+	+	+	+	+	-	11
2	+	+	-	+	+	+	+	+	+	-	+	-	9
3	+	-	-	+	+	+	+	+	+	-	+	-	8
4	+	-	+	+	+	+	+	+	+	-	+	-	9
5	+	+	+	+	+	+	+	+	+	-	+	-	10
6	+	-	+	+	+	+	+	+	+	+	+	-	10
7	+	+	+	+	+	+	+	+	+	+	+	-	11
8	+	+	+	+	+	+	+	+	+	-	+	-	10
9	+	-	-	+	+	+	+	+	+	-	+	-	8
10	+	-	+	+	+	+	+	-	+	+	+	-	9

When Table 3 was examined, it was seen that the activities aimed to be gained in laboratory activities designed based on SPS and hypothesis setting and testing can be achieved with 11 SPS, at most with first and seventh experiments. On the other hand, it was seen that the third and ninth experiments (with eight SPS) were the experiments in which the least number of skills can be gained. In addition, it was aimed to gain 10 SPS in the fifth and sixth experiments and nine SPS in the second, fourth, eighth, and 10th experiments.



2. **Etkinliğin Amacı**

Bulunulan ortamda suyun kaynama sıcaklığını araştırmak, kaynama sıcaklığına etki eden **değişkenleri tahmin etme,** su ve tuzlu suyun kaynama noktalarını **ölçme,** termometre gibi bir laboratuvar aracını doğru ve etkili bir şekilde kullanma, sonuçları **yorumlama,** su ve tuzlu suyun kaynama noktaları arasındaki farkın nedenini **ifade edebilme,** günlük hayatta sıkça kullandığımız düdüklü tencerenin çalışma prensibini keşfetmek vb bilimsel süreç becerilerini kazanmak.

Kurulabilecek Örnek Hipotezler (BSB-2.1, BSB-2.2)

Yapacağınız etkinlik konusundan hareketle; suyun kaynama noktası, buharlaşma, yoğunlaşma ve/veya damıtma işlemleri ve bu özelliklere etki eden etki eden değişkenleri dikkate alarak aşağıda verilen örnek test edilebilir hipoteze benzer en az bir en fazla üç adet araştırılabilir ve test edilebilir hipotez kurunuz.

Örnek hipotez:

Deniz seviyesine göre yükselti (rakım) değiştikçe sıvıların kaynama sıcaklığı farklılaşır.

3. **Deneyde Kullanılabilecek Örnek Malzemeler:**

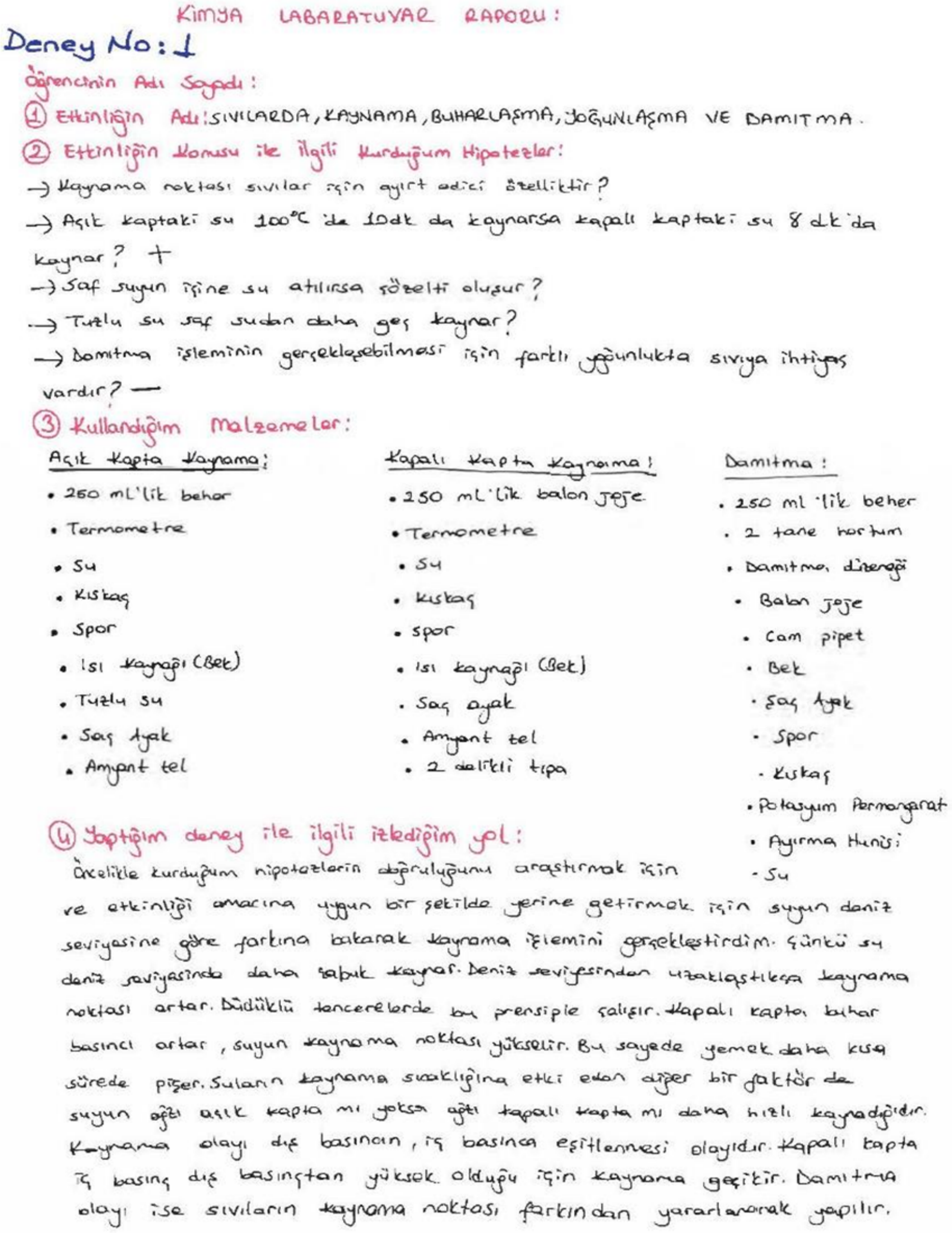
a) <u>Açık kapta kaynama:</u>

- 250 mL beher
- Termometre
- Su
- Kıskaç
- Spor
- Isı Kaynağı (Bek)
- Tuzlu su (Farklı cins tuzdan oluşan)
- Saç ayak
- Amyant tel

Figure 1. A section from the designed experiment sample

Data Collection Tool

Content analysis was made on the experimental reports of the students who applied the experiments developed in accordance with the constructivist laboratory approach, SPS, and the experimental technique based on hypothesis, and the results were evaluated. A section from a Student report sample was shown in Figure 2.



KIMYA LABARATUVAR RAPORU:

Deney No: 1

Öğrencinin Adı Soyadı:

① Etkinliğin Adı: SIVILARDA, KAYNAMA, BUHARLAŞMA, YOĞUNLAŞMA VE DAMITMA.

② Etkinliğin konusu ile ilgili kurduğum Hipotezler:

→ Kaynama noktası sıvılar için ayırt edici özelliktir?

→ Açık kaptaki su 100°C 'de 10dk da kaynarsa kapalı kaptaki su 8 dk 'da kaynar? +

→ Saf suyun içine su atılırsa çözelti oluşur?

→ Tuzlu su saf sudan daha geç kaynar?

→ Damıtma işleminin gerçekleşebilmesi için farklı yoğunlukta sıvıya ihtiyaç vardır? —

③ Kullandığım Malzemeler:

Açık Kapta Kaynama:	Kapalı Kapta Kaynama:	Damıtma:
• 250 mL'lik beher	• 250 mL'lik balon joje	• 250 ml 'lik beher
• Termometre	• Termometre	• 2 tane hortum
• Su	• Su	• Damıtma düzeneği
• Kıskaç	• Kıskaç	• Balon joje
• Spor	• Spor	• Cam pipet
• Isı kaynağı (Bek)	• Isı kaynağı (Bek)	• Bek
• Tuzlu su	• Saç ayak	• Saç Ayak
• Saç Ayak	• Amyant tel	• Spor
• Amyant tel	• 2 delikli tıpa	• Kıskaç
		• Potasyum Permanganat
		• Ayırma Hunisi
		• Su

④ Yaptığım deney ile ilgili izlediğim yol:

Öncelikle kurduğum hipotezlerin doğruluğunu araştırmak için ve etkinliği amacına uygun bir şekilde yerine getirmek için suyun deniz seviyesine göre farkına bakarak kaynama işlemini gerçekleştirdim. Çünkü su deniz seviyesinde daha çabuk kaynar. Deniz seviyesinden uzaklaştıkça kaynama noktası artar. Düdüklü tencerelerde bu prensiple çalışır. Kapalı kapta buhar basıncı artar, suyun kaynama noktası yükselir. Bu sayede yemek daha kısa sürede pişer. Suların kaynama sıcaklığına etki eden diğer bir faktör de suyun ağzı açık kapta mı yoksa ağzı kapalı kapta mı daha hızlı kaynadığıdır. Kaynama olayı dış basıncın, iç basınca eşitlenmesi olayıdır. Kapalı kapta iç basınç dış basınçtan yüksek olduğu için kaynama gecikir. Damıtma olayı ise sıvıların kaynama noktası farkından yararlanarak yapılır.

Figure 2. A section from a Student report sample.

Data Analysis

Data on hypothesis-building skills were determined on student experiment reports by analyzing content. In addition, content analysis was performed by an independent researcher specialized in this field, and the validity of the hypotheses was checked by the expert.

FINDINGS

For each experiment, data on hypothesis-building skills obtained from content analysis on student activity reports are given in Table 4. When Table 4 was examined, it was seen that the first experiment had the highest rate (69.8%) in terms of establishing only one meaningful and testable hypothesis sentence, while this rate was the lowest in the third experiment (35.7%). When evaluated in terms of making two or more meaningful and testable hypothesis sentences, it was seen that the ninth experiment had the highest rate (44.7%), while the fifth experiment had the lowest rate (12.2%). The rate of those who could not make a meaningful and testable hypothesis sentence or who set it wrong was found to be the highest rate (39.4%) in the second experiment and the lowest rate (7.2%) in the ninth experiment.

The proportion of those who never set up a meaningful and testable hypothesis sentence or set it incorrectly decreased significantly as the weeks progressed, especially after the fifth week. In addition, a significant increase was observed in the rate of establishing only one meaningful and testable hypothesis sentence after the fifth week.

Table 4. Hypothesis-building skills

Experiments	The proportion of those who established only one meaningful and testable hypothesis sentence (%) (A)	The proportion of those who established two or more meaningful and testable hypothesis sentences (%) (B)	The proportion of those who never set up a meaningful and testable hypothesis sentence or who set it incorrectly (%) (C)	The proportion of those who established at least one or more meaningful and testable hypotheses (%) (D=A+B)
Experiment 1: Boiling, Evaporation, Condensation, and Distillation in Liquids	69.8	19.8	10.4	89.6
Experiment 2: Physical and Chemical Changes in Substances	44.5	16.1	39.4	60.4
Experiment 3: Hydrogen Gas and Combustion Reaction	35.7	32.3	32	68
Experiment 4: Stoichiometry	38.9	26.7	34.4	65.6
Experiment 5: Investigation of Acids and Bases: Neutralization Reactions	68.7	12.2	19.1	80.9
Experiment 6: Determination of Heat-Temperature Difference of Different Materials with Equal Mass	65.3	14.2	20.5	79.5
Experiment 7: Determining the Amount of Energy in Foods	48.4	35.8	15.8	84.2
Experiment 8: Solubility and Inter-Particle Interactions in Solutions	52.2	34.8	13	87
Experiment 9: Interaction Between Particles and Surface Tension in Liquids	48.1	44.7	7.2	92.8
Experiment 10: Hess's Law	58.1	28.7	13.2	86.8
Average Value	53	26.5	20.5	79.5

Note 1: The number of reports evaluated for each experiment is 31.
Note 2: Other incorrect hypotheses constructed by students who set at least one correct hypothesis have not been taken into account.

When the data about the hypotheses formed by the students and the suggestions reported by the students were evaluated, it was observed that the experiments designed were applicable, that these experiments were appropriate for the students' levels and the curriculum and that the students gained the ability to formulate hypotheses at a significant rate.

When Table 4 was examined, it can be said that there was an increase in the rate of those who made at least one or more significant and testable hypotheses in the fifth week and onwards. The reason(s) of the high rate in the first experiment was that the students were presented with a sample hypothesis as a clue and for informational purposes, and the content of the subject was broad and related to common events in daily life, so it can be thought that the students were experienced on these issues.

DISCUSSION

According to the data in Table 4, it was seen that most of the students had at least one hypothesis sentence, and some of them never had. The results obtained in this study are similar in some respects to the results obtained in the study conducted by Bolat et al. (2012). They reported that students had difficulty forming hypotheses. In this study, the rate of students who could not make a meaningful and testable hypothesis statement was determined as 20%. In addition, Turan (2018) stated that the number of students who failed to make the correct hypothesis proposition was higher than the number of students who made the correct hypothesis. On the contrary, in this study, the proportion of students who made at least one or more correct hypotheses was higher than those who could never formulate correct hypotheses. It is thought that the reasons for this are encouraging the students to do research on the subject before the activity and giving the students a sample hypothesis as a clue. Şimşek & Kabapınar (2010) also stated that students had problems with their hypothesis-building skills.

CONCLUSION AND RECOMMENDATIONS

In this research process, the educational material developed within the scope of laboratory applications based on the constructivist learning approach was used for the General Chemistry Laboratory-I course, and the hypothesis-building skills of the students were evaluated.

Application results were reported by the students. As a result of the content analysis made over the student reports, it was concluded that a significant part of the hypotheses established could be investigated and tested, and no significant difficulties were encountered during the applications. As a result of these analyses, it was determined that the rate of students who could establish testable and meaningful hypotheses (80%) was higher than the rate of students who could not establish such hypotheses (20%). In addition, it can be said that such activities designed for the acquisition of process skills can contribute positively to both the acquisition of adequate process skills to the students and the permanence of these skills.

- Within the scope of science education applications, the applications designed based on the constructivist laboratory approach and developed in terms of gains related to the process skills should be included more in the research and inquiry processes.

- It may be suggested that similar applications should be made within the scope of other applied basic science courses such as biology, physics.

- In the field of science education, it is important to adequately evaluate the effects and efficiency of the activities designed based on the constructivist laboratory approach and developed in terms of process skills. For this reason, it can be suggested to conduct studies on the students' scientific process skills levels and whether these skills differ in terms of various variables, and whether there are positive developments in these skills in the education and training process.

Declaration of Conflicting Interests

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Author contribution statements:

This study has been produced from the master's thesis. Şule Yaz is the author who conducted his thesis research and Zekeriya Yerlikaya is the author who supervised the thesis.

All authors discussed the results and contributed to the final manuscript.

Researchers' contribution rate The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

All stages of the study were carried out in accordance with ethical principles. Since the implementation of the study was carried out before 2020, the Ethics Committee Approval Document was not received.

Conflict of Interest: The authors declare that they have no conflict of interest.

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