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Öğrencilerin Bazı Fizik Kavram, Olay ve Olguları Diyagramlarla Açıklamaları ve Günlük Yaşamla İlişkilendirmeleri

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ÖZET

Bu çalışmada öğrencilerin fen kazanımları dikkate alınarak hazırlanan sorular kapsamında fizik kavram, olgu ve olaylara ilişkin öğrenciler tarafından oluşturulan diyagramlar aracılığıyla öğrencilerin kavramsal öğrenmelerinin değerlendirilmesi amaçlanmaktadır. Araştırmanın bir diğer amacı ise öğrencilerin fizik kazanımlarıyla ilgili bilimsel kavram, olgu ve olayları günlük hayatla ilişkilendirme düzeylerini incelemektir. Nitel araştırma yaklaşımlarından biri olan fenomenolojik araştırma deseni kullanılmıştır. Araştırmanın çalışma grubunu üç devlet ortaokulunda öğrenim gören 123 7. sınıf öğrencisi oluşturmaktadır. Araştırmaya birinci okuldan 38, ikinci okuldan 62 ve üçüncü okuldan 23 öğrenci katılmıştır. Veriler araştırmacılar tarafından geliştirilen bir form aracılığıyla toplanmış ve toplanan verilere doküman analizi yöntemi uygulanmıştır. Öğrencilerin oluşturduğu diyagramların analizi sonucunda öğrencilerin fizik kavram, olay ve olgularına ilişkin oluşturdukları diyagramların çoğunun "anlamama" kategorisinde olduğu sonucuna varılmıştır. Yani çoğu öğrenci soruları boş bırakmış, tekrarlamış veya anlaşılmaz diyagramlar oluşturmuştur. Ayrıca öğrencilerin çoğu fen bilgisi dersindeki kavram, olgu ve olayları günlük hayatla ilişkilendirememiştir.

Anahtar Kelimeler: Kavram Öğrenme, Diyagram, Fizik Eğitimi, Nitel Araştırma, Ortaokul Öğrencileri

Etik Kurul İzni Tarih / Sayı : Gazi Üniversitesi Etik Komisyonu, 11 September 2022 , No: 2022 - 629

GENİŞ ÖZET

Amaç

Bu çalışma ile fen kazanımları dikkate alınarak hazırlanan sorular kapsamında fizik kavram, olgu ve olaylarına yönelik öğrencilerin oluşturduğu diyagramlar aracılığıyla öğrencilerin gerçekleştirdiği kavramsal öğrenmelerin değerlendirilmesi amaçlanmıştır. Çalışmanın bir diğer amacı öğrencilerin fen dersi fizik konusu kazanımlarına ait bilimsel kavram, olgu ve olaylarının günlük hayat ile ilişkilendirme düzeylerinin incelemek olarak belirlenmiştir.

Yöntem

Bu araştırma, nitel araştırma yaklaşımlarından biri olan olgubilim deseninde tasarlanmıştır. Araştırmanın çalışma grubunu, Bingöl ili Solhan ilçesine ait resmi okullarda öğrenim gören ortaokul 7. sınıf öğrencileri oluşturmaktadır. Araştırmada, çalışma grubu aşamalı örnekleme yöntemi kullanılarak seçilmiştir. Araştırmanın çalışma grubunu, Bingöl ili Solhan ilçesinde üç farklı resmi ortaokulda 7. sınıfta öğrenim gören 123 öğrenci oluşturmuştur. Araştırmaya dâhil edilen birinci okuldan 38 öğrenci, ikinci okuldan 62 öğrenci ve üçüncü okuldan 23 öğrenci araştırmaya katılmıştır. Araştırmada doküman aracılığıyla veri toplama tekniği kullanılmıştır. Bu araştırmada öğrencilerden toplanan veriler iki farklı kodlama aracılığıyla analiz edilmiştir. Öğrencilerin kazanımlara ilişkin sorulara yönelik

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diyagram çizimleri kapalı kodlama tekniğiyle analiz edilmiştir. Günlük yaşamda nerede karşımıza çıkmaktadır veya hangi olaya benzetilebilir? sorusu ise açık kodlama tekniğiyle analiz edilmiştir. Analizleri iki araştırmacı ayrı ayrı tekrarlamış ve uyum indeksi ,82 olarak hesaplanmıştır.

Sonuçlar

Öğrencilerin oluşturduğu diyagramların analizi sonucu öğrencilerin fizik kavram, olay ve olgularına yönelik oluşturduğu diyagramların birçoğunun "anlamama" kategorisinde olduğu sonucuna ulaşılmıştır. Bir başka ifadeyle öğrencilerin çoğunluğu soruları boş bırakmış, soru tekrarına düşmüş veya anlaşılmayan diyagramlar oluşturmuştur. Araştırmada ikinci olarak öğrencilere yönlendirilen fizik kazanımlarına ilişkin sorular kapsamında fen bilimleri dersi fizik konusu bilimsel kavram, olay ve olgularını günlük hayatla ilişkilendirme düzeyleri ölçülmüştür. Öğrenci örnekleri soruya verilen cevabın uygunluğuna göre kategorilere ayrılmıştır. Bu kapsamda öğrencilerin büyük çoğunluğu fen dersine yönelik kavram, olgu ve olayları günlük hayatla ilişkilendirememiştir. Çalışma sonucunda öğrencilerin birçoğu günlük yaşam ile ilişkilendirme bölümünü boş bırakmıştır.

Examining Students' Explanations of Some Physics Topics with Diagrams and Association of Them with Daily Life

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ABSTRACT

This study aims to evaluate the students' conceptual learning through the diagrams created by the students regarding the physics concepts, phenomena, and events within the scope of the questions prepared by considering the science objectives of the students. Another purpose of the study was to examine the level of associating students' scientific concepts, facts, and events related to physics objectives with daily life. Phenomenological research design was used as one of the qualitative research approaches. The research study group comprised 123 7th-grade students in three public secondary schools. Thirty-eight students from the first school, 62 from the second school, and 23 from the third school participated in the research. Data were collected through a form developed by the researchers, and a document analysis method was applied to the collected data. As a result of the analysis of the diagrams created by the students, it was concluded that most of the diagrams created by the students regarding physics concepts, events, and phenomena were in the "no understanding" category. In other words, most students left the questions blank, repeated, or created incomprehensible diagrams. In addition, most students could not relate science class concepts, facts, and events to daily life.

Keywords: Concept Learning, Diagram, Physics Education, Qualitative Research, Secondary School Students

Ethical Committee Date / Number : Gazi University Ethical Committee , 11 September 2022 , No: 2022 - 629

1. Introduction

We live in a world where science has become an integral part of our lives, with discoveries every day (Vieira, Tenreiro-Vieira & Martins, 2011). Therefore, in this age of science we live in, to reach scientific information fastest, we must raise individuals who think quickly, question, and produce. The most effective way to achieve this is through a good science education (Cesur, 2019; Temizyürek & Türktan, 2015; Tekbıyık & Akdeniz, 2008; Yenice, Özden & Balcı, 2015).

When science is mentioned, the first basic sciences come to mind (Akgün & Özenoğlu, 2018). Basic sciences are branches of science that play an active role in scientific thinking, decision-making, problem-solving, and an individual's understanding and interpretation of the world (Demirel, 2016). Therefore, the quality of science education is vital in adapting to this rapidly developing and changing world (Çakıcı, 2009). In trying to adapt to this rapidly developing and changing world, humans first want to make sense of the environment and the universe in which they live to solve their problems (Soylu & Memişoğlu, 2019). For this reason, he distinguishes the differences and similarities between entities, events, and phenomena and uses concepts to save them from possible confusion in his mind (Çetinel, 2019). Concepts facilitate learning and remembering, help us distinguish between right and wrong, provide a high level of academic success, and enable us to bring rational solutions to the problems encountered (Doğanay, 2005; Soylu & Memişoğlu, 2019).

Multiple representations have a critical role in learning the concepts and in the relationship to be established between the concepts. The use of representations and the ability to switch between these representations are expressed as an essential indicator of how well students can learn a concept (Can, 2014). According to Sezgin (2019), multiple representations enable concepts to be taught more comprehensively. Aslan and Yadigaroğlu (2014) stated that models with multiple representations provide different perspectives and physical appearances for explaining the phenomenon. Models explain scientific events, concepts, and processes (Akbay, Özel, Taşdelen, Önder & Güven Yıldırım, 2022; Can, 2014; Özel, Taşdelen, Güven Yıldırım & Önder, 2022; Taşdelen & Özel, 2024). Many concepts in science require

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students to create mental models (Çelik, 2015). The model can be a diagram, a picture, a map, a graphic, or a photograph (Güneş, Gülçiçek & Bağcı, 2004).

Diagrams, one of the multiple representation models, are an essential tool for learning. Diagrams give information about concepts, processes, and relations between concepts (Barker- Plummer, Cox & Swobada, 2006). Diagrams show several events together. It allows students to explain and compare events in a cause-effect relationship. Diagrams, which ensure the permanence of the knowledge, show the relations between the knowledge, facilitate the recall of the knowledge, and keep the knowledge forming the subject together. This way, diagrams simplify and schematize topics (Durmuş & Kuruyer, 2020). Diagrams are ubiquitous in scientific fields since diagrams describe the course of almost everything (Barker Plummer, Cox & Swobada, 2006). Diagrams are a thinking method used to reconceive the problem situation, make inferences about the problem situation, and provide visualization of the verbal expression (Pantziara, Gagatsis & Elia, 2009). In recent years, it has been observed that the use of diagrams in education has increased in concept learning and the evaluation of conceptual knowledge (Matovu, Won, Treagust, Mocerino, Ungu, Tsai, & Tasker, 2023).

In this study, the feature of the diagrams to convey verbal expression to visuality has been utilized. In this context, it aims to evaluate the students' conceptual learning through the diagrams created by the students regarding the physics concepts, phenomena, and events within the scope of the questions prepared by considering the science objectives of the students. As long as a learned knowledge meets the needs of students in daily life, the student will feel the need and be interested in learning that knowledge. The more students associate the information they learn with daily life, the higher their learning level will be (Kara, 2016). For this reason, another purpose of the study was to examine the level of associating students' scientific concepts, facts, and events related to physics objectives with daily life.

2. Method

2.1. Ethical Committee Permission

The present study was approved by the …… University Ethics Committee (Reference Number: 2022 - 629). All participants were informed about the research objectives and read and signed an informed consent form.

2.2. Research Design

In this study, phenomenological research design, which is one of the qualitative research approaches, was used. The primary purpose of the phenomenological method is to describe the basic structure or essence of experience by focusing on experiences (Merriam, 2013).

2.3. Study Group

The study group consists of secondary school 7th-grade students in public schools in the Solhan district of Bingöl province. The study group was selected using the two-stage sampling method. In this direction, the criterion sampling method was used in the first stage, and the typical case sampling method was used in the second stage. Three ordinary, usual, regular schools were selected. The research study group comprised 123 7th-grade students in three public secondary schools. Thirty-eight students from the first school, 62 from the second school, and 23 from the third school participated in the research.

2.4. Data Collection Tool

Data were collected through a form developed by the researchers, and a document analysis method was applied to the collected data. Document analysis includes the collection and analysis of written materials containing information about the situation, event, or phenomena that are intended to be investigated (Yıldırım and Şimşek, 2016). In this direction, a form was developed by the researchers for students to explain scientific concepts, facts, and events with diagrams. First of all, it was considered that the questions were in a visualizable structure so the students could explain them with a diagram. Afterward, possible units, subjects, and objectives suitable for this criterion were determined. Five questions were prepared from this unit and objectives. Opinions were received from three science field experts for these questions. Field experts evaluated the content validity of this developed form, its suitability for visualization through diagrams, and the intelligibility of the items. As a result of the evaluations of the field experts, some questions were changed, and some questions were removed. For example, one of the field experts did not find it appropriate to express some questions with diagrams. In the final form, there were three questions about the physics objectives in the science curriculum. In addition, there was one more question about the relationship of each question with daily life. The distribution of the physics questions in the final form according to the unit, subject, and objectives of the science course curriculum is given in Table 1.

Table 1
Distribution of Physics Questions in the Form of Science Curriculum Unit, Subject and Objectives

Item	Grade level	Unit name	Subject	Objective
Why does sound travel faster in solids than in liquids and gases?	6th grade	Sound and Features / Physical Events	Speed of Sound	Compares the speed of sound in different environments
How do parachutes glide down to the ground by reducing the effect of gravity?	5th grade	Measuring Force and Friction / Physical Events	Frictional force	Generates new ideas to increase or decrease friction in daily life
When you compare the cables of dishwashers and washing machines with the cable of a mobile phone charger, you have observed that their thickness is different. What is the reason for this? (Other variables are fixed.)	6th grade	Conduction of Electricity / Physical Events	Electrical Resistance and Dependent Factors	Predicts the variables on which the brightness of a light bulb in an electrical circuit depends and tests predictions by experiments

2.5. Data Collection

First of all, after obtaining the permission of the X University Ethics Committee and the necessary permissions from the Bingöl Provincial Directorate of National Education to conduct research in schools, face-to-face interviews were conducted with school administrators and science teachers in three secondary schools selected for the study. In these interviews, information was given about the purpose and scope of the research and the application process to be carried out with the students. Afterward, appointments were made for the application by interviewing the Science teachers. In the second stage, the students in the study groups were informed about diagrams and the objectives of the items in the form within one class hour. In this context, a presentation, a question-answer, and then a classroom discussion under the leadership of the teacher were made. In the third stage, the form was distributed to the students. According to the instructions in the form, students were asked to visualize their views and comments on the questions through diagrams and to associate them with daily life. For this, students were provided to work individually. Students were given one lesson hour for this process. At the end of their studies, the forms of the students were collected.

2.6. Analysis of Data

The data collected from the students were analyzed through two different coding techniques. The diagram drawings of the students for the items about the objectives were analyzed with the closed coding technique. Students' understanding levels based on diagrams were classified into five categories based on those developed by Abraham, Grzybowski, Renner, and Marek (1992) (Table 2). In this respect, five categories were determined: No understanding, Specific misconception, Partial understanding with specific misconception, Partial understanding, and Sound understanding. The diagrams drawn by the students for each question were examined in detail by the researcher and coded according to the determined categories. Then, the frequency and percentage of the categories were calculated.

Table 2
Categories Used in the Analysis of Diagrams Drawn by Students

Categories	Description of the Category
No understanding	Blank, irrelevant, and incomprehensible diagrams
Specific misconception	Diagrams consisting of unscientific, incorrect information
Partial understanding with specific misconception	Diagrams with correct information as well as misconceptions
Partial understanding	Diagrams with missing but correct information
Sound understanding	Diagrams containing accurate, complete, or nearly complete information

Regarding each question in the form, "Where does it occur in daily life, or to what event can it be compared?" The question was asked to the students. The students' answers to this question were analyzed using the open coding technique. Two researchers repeated the analyses separately, and the inter-rater reliability was calculated as .82.

3. Findings

Results Regarding the First Question

The analysis results of the diagrams drawn by the students for the question "What is the reason why sound is transmitted faster in solid substances than in liquid and gaseous substances?" are presented in Table 3.

Table 3
Analysis Results of Diagrams Drawn by Students

Category	f	%
No understanding	40	32,5
Specific misconception	10	8,1
Partial understanding with specific misconception	12	9,8
Partial understanding	49	39,8
Sound understanding	12	9,8
Total	123	100,0

When Table 3 is examined, it is seen that most students (39.8%) are in the "Partial understanding" category. In addition, 32.5% of the students are in the "No understanding" category. In addition, approximately one-fifth (17.9%) of the students have misconceptions. Finally, about one in 10 students is in the Sound understanding category (9.8%). Sample diagrams are given in Figure 1 and Figure 2.

Examples of diagrams drawn by students

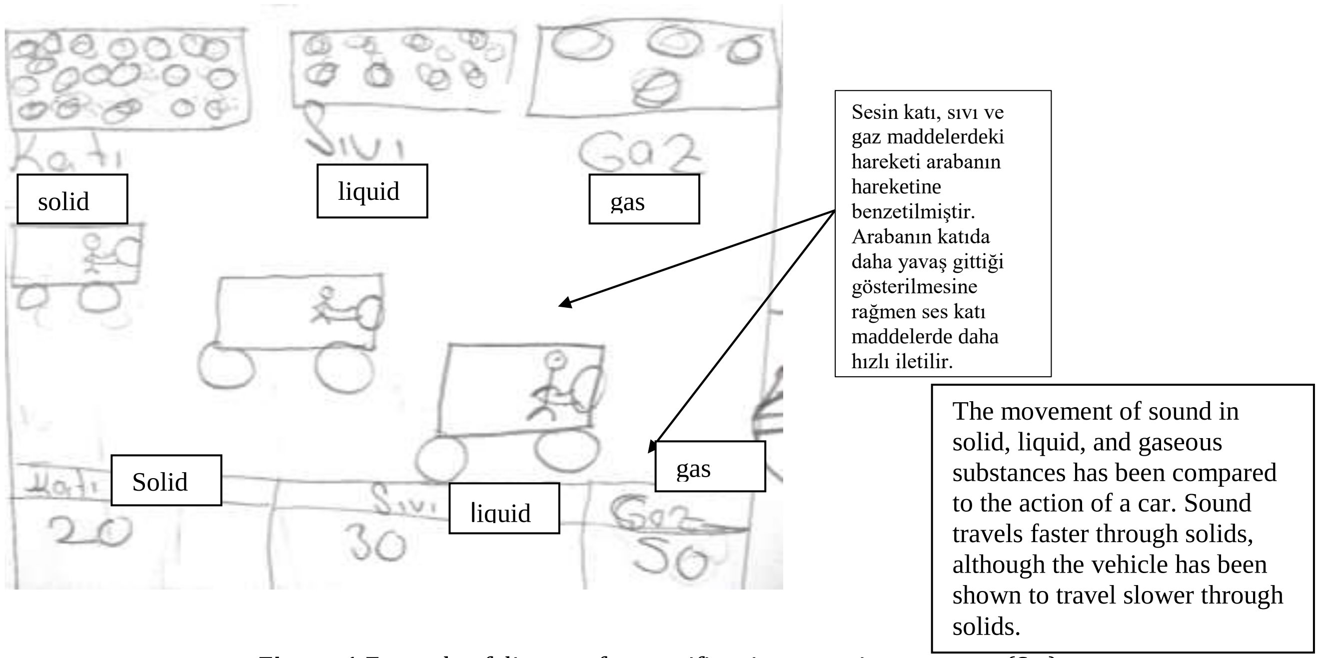

Figure 1 Example of diagram for specific misconception category (S53)

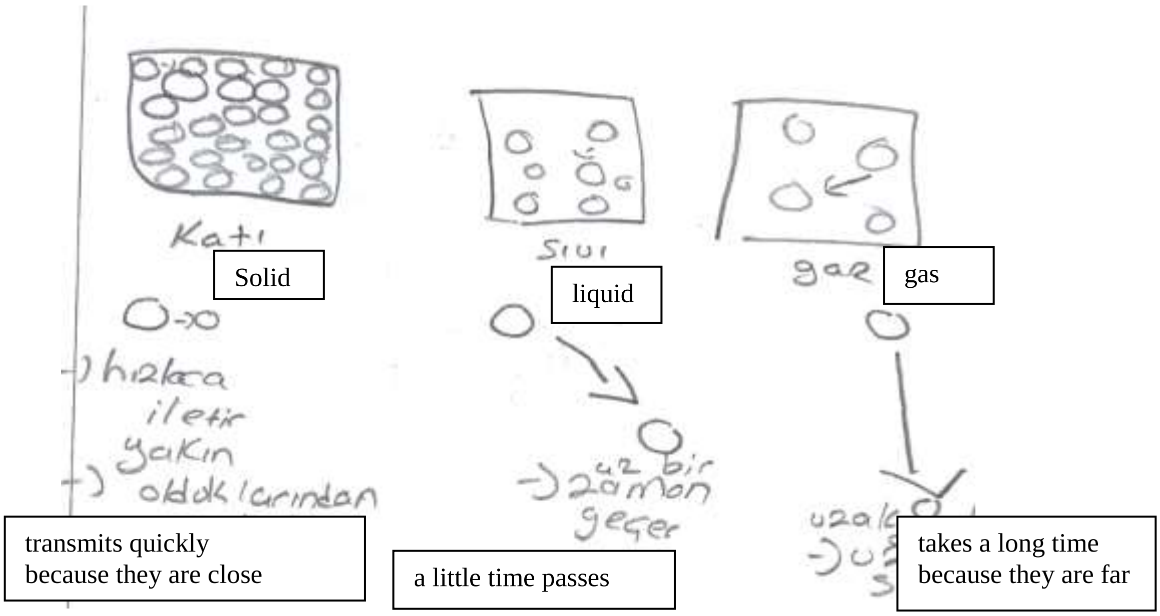

Figure 2 Example of diagram for sound understanding category (S18)

The analysis results of the daily life examples they gave regarding the question, "What is the reason why sound is transmitted faster in solids than in liquids and gases?" are presented in Table 4.

Table 4
Analysis Results of Students' Daily Life Examples

Theme	Code	f	%
Appropriate example	Vibration on train tracks	22	17,89
	Listening to music on the phone	4	3,25
	Knocking on the table	3	2,44
	Talking with headphones	2	1,63
	Propagating sound in space	2	1,63
	Shouting through a pipe	1	0,81
	Weddings, concerts, etc.	1	0,81
	Sound in the sand	1	0,81
Inappropriate	Meaningless answers (e.g., while cooking, the states of water, etc.)	27	21,95
	While listening to a lecture	2	1,63
Blank	Blank	58	47,15

Table 4 includes the content analysis results of their answers to the question, "Where does it occur in daily life, or to what event can it be compared?". When the students' answers were examined, eight basic codes were found in the appropriate examples category: vibration on train tracks, listening to music on the phone, knocking on the table, talking with headphones, propagating sound in space, shouting through a pipe, wedding, concert, etc., and sound in the sand. The majority of the students gave the example that while we cannot hear the sound of an approaching train through the air, we can listen to it when we put our ear to the train track (f = 22). While some students stated that they put their phones in a glass or lean them against the wall when the sound is low while listening to music on their phones (f = 4), some students stated that they hear the sound stronger when they put their ears to it than when they did not.

While two students stated that using headphones while talking on the phone is more effective in terms of sound transmission, another two students indicated that sound is not transmitted in a place with no particles, giving the example that sound does not spread in space. In addition, while one student responded to shouting through a pipe, another student stated that the waves were louder on the sand at the beach, and another student noted that the sound was louder in places such as weddings and concerts. At the same time, a student said, "*I compare this event to water. Because water flows in a flat area but not in a tight place*." With the example of (S49), the student stated that water does not flow in a cramped place. But this example is wrong. Sound is transmitted better because the particles of the solid material are closer to each other. In addition, some students' answers in the inappropriate examples category, which were not related to the topic, contained incorrect information or repeated the question exactly, were accepted as meaningless answers (f = 27). At the same time, while listening to the lecture, the answers under the code (f = 2) were included in the category of inappropriate examples because they were not suitable examples to express why solids transmit sound better than liquids and gases. Finally, many students left the answer blank (f = 58). Appropriate and inappropriate examples of some students regarding this question are presented below:

Examples for appropriate category;

- *"When we put our ear on the train track, the sound is better, when we lift our ear, the sound is less because the sound is transmitted better on the solid" (S_{40})*
- *"While waiting for the train, we lay our heads on the track and listen to see if it has arrived" (S_{99})*
- *"We turn on music on the phone, the sound is low because it is in a gaseous environment, but when we put it in a container, the sound gets louder" (S_{73})*
- *"While the sound can be heard well with headphones, it cannot be heard well in liquid and gaseous environments" (S_{51})*
- *"Sound is transmitted better with electrical wires" (S_{32})*

- *“My friend shouting at me through the air, my friend shouting at me through the pipe” (S_{102})*

Examples for inappropriate category;

- *“Sound is heard because there are very few gaps in gases” (S_{67})*
- *“This happens when our mother yells at us” (S_{74})*

Results Regarding the Second Question

The analysis results of the diagrams drawn by the students for the question "How do parachutes glide down to the ground by reducing the effect of gravity?" are presented in Table 5.

Table 5
Analysis Results of Diagrams Drawn by Students

Category	f	%
No understanding	59	48,0
Specific misconception	11	8,9
Partial understanding with specific misconception	12	9,8
Partial understanding	36	29,3
Sound understanding	5	4,1
Total	123	100,0

When Table 3 is examined, it is seen that nearly half of the students (48%) are in the category “not understanding.” However, approximately one-third of the students (29.3%) are in the “Partial understanding “category. In addition, 8.9% of the students are in the category of “Specific misconception,” and 9.8% are in the category of “Partial understanding with specific misconception “. In addition, it can be said that only five students (4.1%) are in the Sound understanding category, and in this respect, they can fully explain the relevant subject with diagrams. Sample diagrams are given in Figure 3 and Figure 4.

Examples of diagrams drawn by students

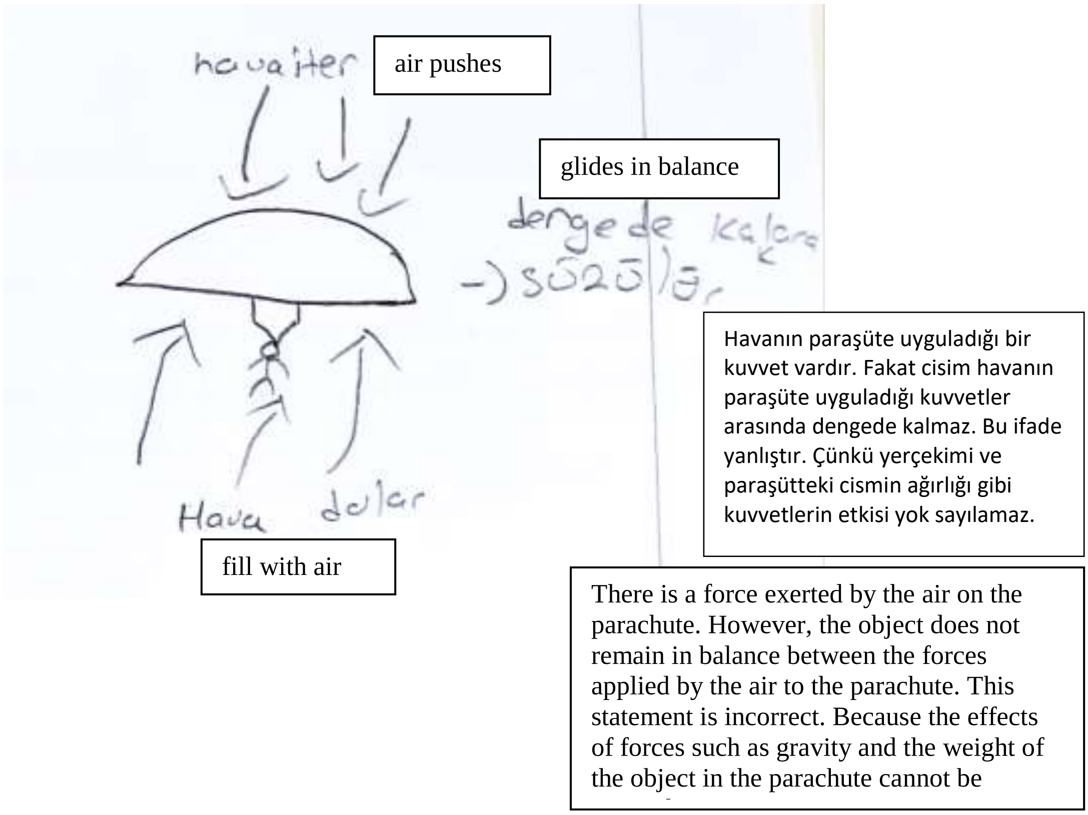

Figure 3 Example of diagram for partial understanding with specific misconception category (S_{18})

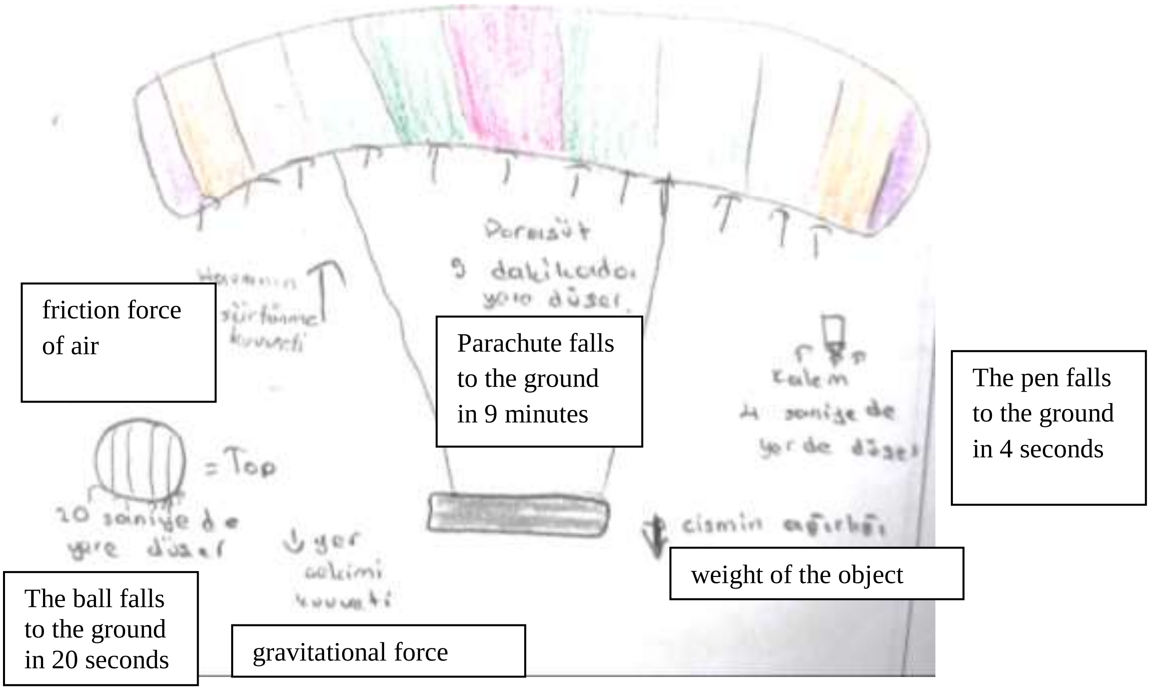

Figure 4. Example of diagram for sound understanding category (S34)

The analysis results of the daily life examples they gave regarding the question, "How do parachutes glide down to the ground by reducing the effect of gravity?" are presented in Table 6.

Table 6

Analysis Results of Students' Daily Life Examples

Theme	Code	f	%
Appropriate example	While skydiving	16	13,01
	Car chain/Winter tire	7	5,69
	Kite	2	1,63
	Inflate the balloon and release it	2	1,63
Inappropriate	Meaningless answers	25	20,33
	Airplanes have pointed ends	7	5,69
	Birds flying in a V shape	3	2,44
Blank	Blank	61	49,59

Table 6 includes the content analysis results of their answers to the question, "Where does it occur in daily life, or to what event can it be compared?". When the students' answers were examined, four basic codes were reached in the appropriate examples category: while skydiving, Car chain/Winter tire, Kite, and inflate the balloon and release it. Most students observed this phenomenon while skydiving (f = 16). In addition, some students gave the example of putting chains or tires on cars in winter, increasing friction (f = 7). In addition, two students compared this phenomenon to the structure of a kite and its flying principle, and two students stated that they observed this phenomenon when they inflated the balloon and released it. Some students gave the example of planes having pointed ends (f = 7). Some students gave the example of birds flying in a V shape or migrating by opening their wings (f = 3). Still, these examples they provided are not examples of increasing the friction force and slowing down the movement as in the question, but the opposite. It is an example of reducing friction and accelerating movement. For this reason, the pointed ends of planes and the V-shape flying of birds are considered inappropriate examples. In addition, the answers of students in the inappropriate examples category that were not related to the topic or repeated the question exactly were considered meaningless answers (f = 25). Finally, many students left the answer blank (f = 61).

Appropriate and inappropriate examples of some students regarding this question are presented below:

Appropriate examples;

• "When we inflate the balloon and release it, the balloon floats can be given as an example" (S73)

• "Attaching chains to car tires in winter" (S3)

• "When we put a hat-shaped paper on the fan, it flies, but when we put a wooden pencil, it does not fly" (S40)

Inappropriate examples;

• "Gas leak" (S106)

• "We sometimes encounter it while watching television" (S74)

• "Birds migrate in the shape of the letter V" (S111)

Results Regarding the Third Question

The analysis results of the diagrams drawn by the students for the question "When you compare the cable of dishwashers and washing machines with the cable of a mobile phone charger, you may have observed that their thicknesses are different. What is the reason of this? (Other variables are fixed.)" are presented in Table 7.

Table 7
Analysis Results of Diagrams Drawn by Students

Category	f	%
No understanding	88	71,5
Specific misconception	6	4,9
Partial understanding with specific misconception	4	3,3
Partial understanding	17	13,8
Sound understanding	8	6,5
Total	123	100,0

When Table 7 is examined, it is seen that most students (71.5%) are in the category "not understanding". In addition, it can be said that a small number of students are in the category " Specific misconception (4.9%)" and " Partial understanding with specific misconception (3.3%)". However, it is seen that a limited number of students achieve " Partial understanding (13.8%)" and " Sound understanding (6.5%)". Sample diagrams are given in Figure 5 and Figure 6.

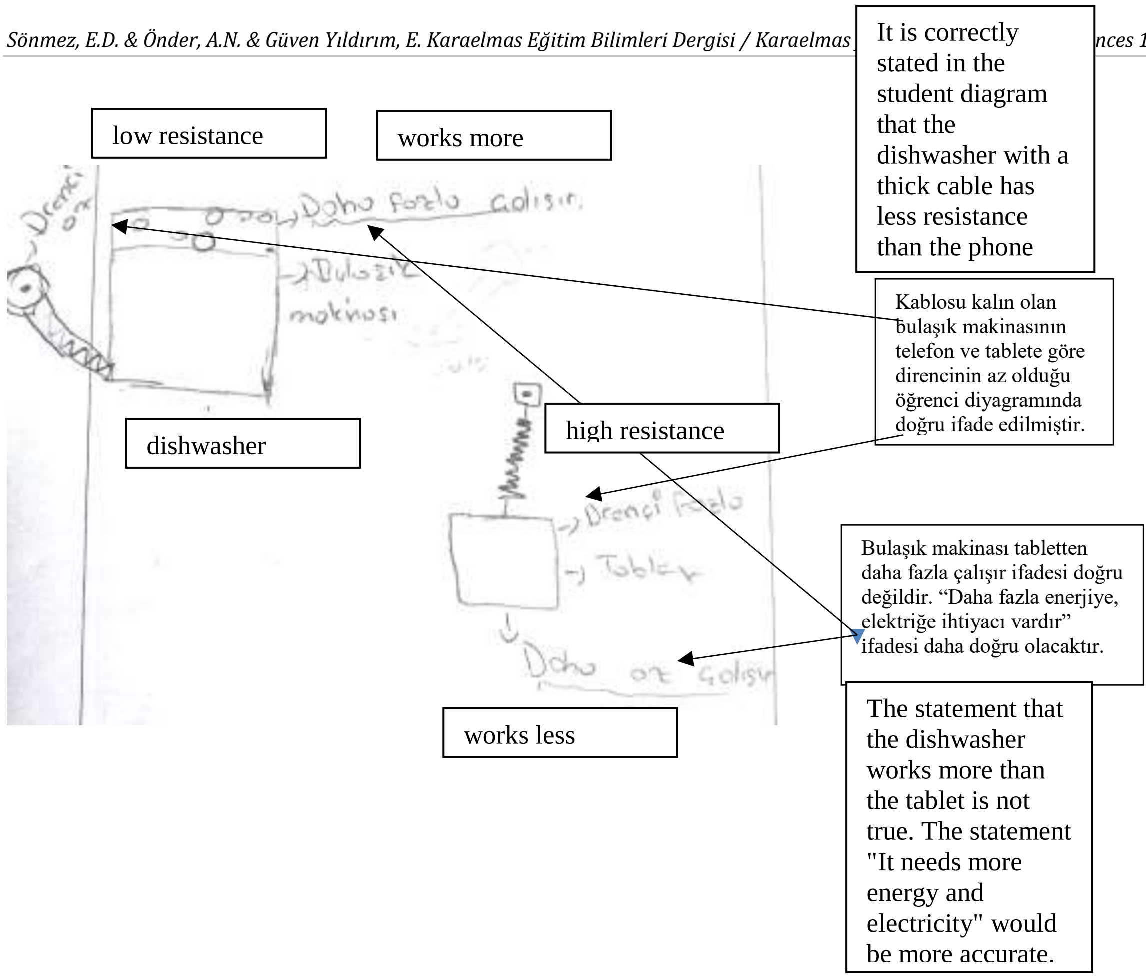

Figure 5. Example of diagram for partial understanding with specific misconception category (S_4)

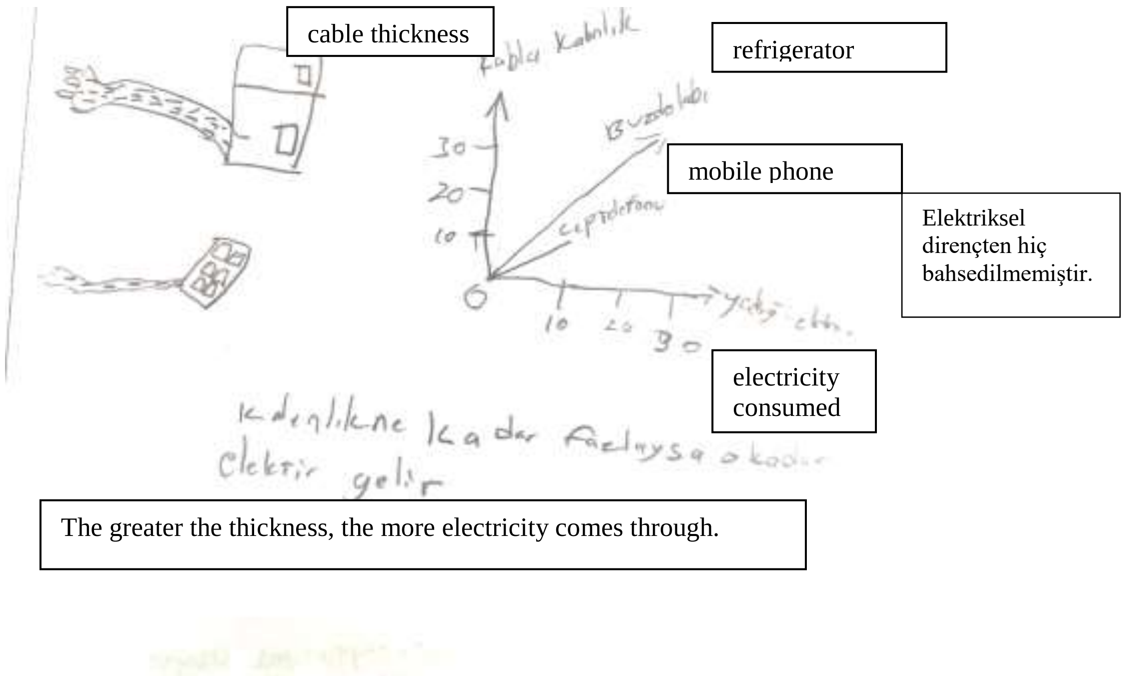

Figure 6. Example of diagram for Partial understanding category (S_{15})

The analysis results of the daily life examples they gave regarding the question, "When you compare the cable of dishwashers and washing machines with the cable of a mobile phone charger, you may have observed that their thicknesses are different. What is the reason of this? (Other variables are fixed.)" are presented in Table 8.

Table 8
Analysis Results of Students' Daily Life Examples

Theme	Code	f	%
Appropriate example	When plugging into a socket	16	13,01
	Electrical cables carried to houses	6	4,88
	transformers	5	4,07
Inappropriate	Meaningless answers (E.g. it happens every day, we see it at home, etc.)	31	25,20
Blank	Blank	65	52,85

Table 8 includes the content analysis results of their answers to the question, "When you compare the cable of dishwashers and washing machines with the cable of a mobile phone charger, you may have observed that their thicknesses are different. What is the reason for this? (Other variables are fixed.)". When the students' answers were examined, three basic codes were reached: When plugging into a socket, Electrical cables carried to houses and transformers. Most students observed that the wires of appliances such as refrigerators and washing machines were thicker than the cables of mobile phone chargers when plugging them into the socket (f = 16). In addition, some students emphasized that the reason for the question is the same as the thickness of the electrical cables carried to houses (f = 6) and the thickness of the electrical wires in transformers. In addition, some students' answers that were not related to the topic or repeated the question verbatim were considered meaningless answers (f = 30). Finally, many students left the answer blank (f = 65). Appropriate and inappropriate examples of some students regarding this question are presented below:

Appropriate examples;

- "Electric cables carried to our house" (S7)
- "The thickness of electric poles is greater. "It has less resistance, more electricity passes" (S52)
- "Thicker wires in transformers" (S111)

Inappropriate examples;

- "It comes out while using the phone in our daily lives" (S46)
- "If there is a problem with the washing machine cables, we will encounter it" (S58)
- "With the technological devices we use, it can be compared to an electric shock" (S35)

4. Discussion and Conclusion

In this study, students were first asked to create diagrams for physics concepts, events, and phenomena in line with the questions asked according to their science course physics objectives. In this context, the diagrams created by the students were divided into five categories according to the subject's learning level: No understanding, Specific misconception, Partial understanding with specific misconception, Partial understanding, and Sound understanding. As a result of the analysis of the diagrams created by the students, it was concluded that most of the diagrams created by the students regarding physics concepts, events, and phenomena were in the "no understanding" category. In other words, most students left the questions blank, repeated, or created incomprehensible diagrams. The reason for this is that students have difficulty in creating diagrams, and some students cannot even start the diagram creation process (Diezmann & English, 2001). Another reason why conceptual learning was not achieved by many of the students in the study group is due to the students not being able to transition to the abstract operations period fully. Many science subjects require abstract thinking (Yağbasan & Gülçiçek, 2003).

There are many studies on diagrams in the field of education (Akgün & Özkar Bulut, 2017; Diezmann, 2005; Diezmann, 2006; Diezmann & English, 2001; Doğmaz, 2016; Durmuş & Kuruyer, 2020; Gobert & Clement, 1999; Liu, Won & Treagust, 2014; Kidman, 2002; McLure vd., 2022; Pantziara vd., 2009; Tippett, 2016). Many of these studies are related to diagram reading skills (Akgün & Bulut Özkar, 2017; Diezmann, 2005; Diezmann & English, 2001; Doğmaz, 2016; Kidman, 2002). However, few studies in the literature evaluate learning about science concepts, events, and phenomena through diagrams (Gobert & Clement, 1999; Matovu et al., 2023; McLure et al., 2022). Among these studies, Gobert and Clement's (1999) studies on plate tectonics with 5th-grade students were asked to create diagrams and summaries while reading a text, and it was concluded that the students had difficulty expressing the subject with diagrams. This result supports the result of our study. In addition, in the study of Matovu et al. (2023), conducted with a sample of university students, it was stated that the majority of the students who expressed the interactions between water molecules in snowflakes with diagrams did not have difficulties in drawing the water molecule structure, recognizing the polarity of a water molecule and recognizing the intermolecular nature of hydrogen bonds. He stated that the reason for this was that the participants in this study were experts in the chemistry undergraduate program and had teaching experience with molecular models. Matovu et al. (2023) also revealed that students struggle to recognize the three-dimensional molecular interactions of hydrogen bonds between water molecules. The reason for this is stated to be that students have difficulty understanding concepts related to abstract science concepts.

In the relevant literature, there are many studies on conceptual learning carried out using different methods and techniques for scientific concepts, events, and phenomena (Demirci & Ahçı, 2016; Demirhan, Önder & Beşoluk, 2017; Duran & Dökme, 2017; İnel, 2012; Karataş, Köse & Coştu, 2003; Wiebe & Stinner, 2010). As a result of the study conducted by Demirci and Ahçı (2016) on light and optics with university students concluded that the students' conceptual understanding levels were low. This result supports the results of the current study.

It can be said that students' misconceptions significantly impact the failure of conceptual learning (Demirci & Ahçı, 2016). At the same time, attitudes towards the course significantly affect the realization of conceptual understanding of the science course. Students who develop a positive attitude towards science succeed more in conceptual learning. In this context, it can be said that affective domain behaviors are effective in individuals' acquisition of cognitive domain behaviors (Erdem et al., 2004).

Secondly, within the scope of the questions about the physics achievements directed to the students in the research, the level of associating the scientific concepts, events, and phenomena of physics with daily life was measured. Student samples are divided into categories according to the appropriateness of the answer to the question. In this context, most students could not relate science class concepts, facts, and events to daily life. As a result of the study, most students left the section relating to daily life blank. The fact that the students' answers to the questions about associating with daily life are different shows that they make different inferences from the events they observe daily (Cansüngü Koray & Bal, 2002). According to Kamaraj's (2009) study, it was stated that secondary school students found the relationship level of the science course curriculum to daily life insufficient, and students had difficulties in associating the information they learned with examples from daily life. Although students can sometimes define the information and concepts they have learned, they cannot find their equivalent in daily life. This situation causes the student to be unable to produce solutions to the problems he encounters in daily life. Thus, learning cannot move from knowledge comprehension to application levels (Taşdemir & Demirbaş, 2010). Failure to associate the learned information with daily life shows that the education provided did not achieve its purpose. For this reason, there is a need for appropriate teaching strategies to enable students to associate the information they learn with daily life (Coştu, Ünal & Ayas, 2007). Güldal and Doğru (2018) taught science with the modeling technique in their study, and they concluded that the lessons taught with the teaching strategies, methods, and techniques that offer students the opportunity to learn by doing-experience contribute positively to students' understanding, learning, and associating science concepts with daily life.

Students who can associate the information they learn in science lessons with daily life increase their interest in science lessons, and this situation makes it easier for them to comprehend the subjects and enables students to be more successful in science lessons (Kara, 2016). Students need to believe that the information they will learn will be useful in forming their interest in the lesson and their desire to learn. For this reason, the information given to the students should be provided concerning daily life (Kıyıcı & Aydoğdu, 2011). In line with the results of this research, it is recommended to give more space to diagrams in the evaluation process of students, as it increases students' awareness of their learning, and to present the science lesson, which includes a lot of abstract concepts, to students in a concrete way.

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The first author contributed 50%, the second author 30%, and the third author 20% contributed to this article.