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Use Of Idealizations In Physics Textbooks

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Abstract – Idealizations have a very important place in the nature of physics. In this study, it is aimed to examine the content of secondary school physics textbooks in terms of the use of idealizations. For this purpose, the data obtained by examining the 9th, 10th, 11th and 12th grade high school physics textbooks were shared. Qualitative research method was used in the research and the data were obtained by document review technique. The research data were analyzed by three researchers using content analysis method. Evaluations were carried out with the subjects that idealizations should take place predominantly. In this context, 26 subjects/concepts were evaluated and it was determined that the textbooks were insufficient in terms of the use of idealizations as a result of the research. It is one of the important results of the study that the use of idealizations in textbooks increases as the grade level increases. Considering that idealizations are an important element of physics learning, it is thought that this situation should be emphasized.

Key words: physics education, idealization, physics textbook

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Introduction

In its broadest sense, physics is the discipline related to the 'hows' of the universe. Physics is a scientific branch investigating the matter, energy in relation to matter and every concept linked with space-time. “Just like all the other physical sciences, physics is also established

upon experimental observations and quantitative measurements. The main goal in physics is to detect the limited number of basic laws governing the natural phenomenon and harness them in developing the theories that can suggest relevant results for prospective experiments. These basic laws employed in theory development are expressed via the mathematical language, bridging the theory with experiment" (Serway & Beichner, 2000, p. 3). In this law and the modellings expressed via mathematical language, idealizations are frequently mentioned. Idealizations represent novel systems some of which specific features are closer to the features in target system (Norton, 2012). In general, idealization is performed to omit small variables, non-disclose the definition of certain variables, imagine limiting situations and accept the permanency or unity of some variables. Idealization is used when we develop physical models, equations or laws about "the real world' by employing sensory-data and as a result 'physics world' is recreated as the simile of real word. In another saying, with respect to exploration, idealization plays a crucial role generally by simplifying and bringing real world closer. Idealization is a key player also in applying physics concepts or physics world in order to grasp and estimate the real world. Broadly, idealization is performed by guiding experiment design, clarify and minimize the inconsistencies between real world and physics world by altering the conditions of idealization (Song, Park, Kwon & Chung, 2000). Scientists mostly aim to simplify what is presented; it is widely attested that if a model is correct in its basis, it can be made more complex afterwards (Fowler, 1997). Some theorists argue that idealizations are major players in the modeling and representation of physical phenomenon. Traditional view states that in reality use of idealizations is pragmatically right: so as to make them solvable and simplified we are required to include idealizations to our equations. Another perspective claims that idealizations are much better at explaining and characterizing dominant features of physical phenomenon. In a different saying, that means these idealized models are much more detailed and much more explanatory than less-idealized models (Batterman, 2009).

Remembering the fact that idealizations have a significant role in the nature of science it is critical that students learn the idealizations and gain awareness on this concept. Song et al.,(2000) argue that in science, particularly in physics, greater attention must be paid to the role of teaching and idealization in learning activities because idealization itself is a main component of learning physics. Idealization approach helps students to notice the association and inconsistency between the real world and physics world. Besides, it may be useful to foster students' creative analysis activities which assist them in actively engaging with idealization. In their research, Cahyadi and Butler (2004) concluded that concurrent teaching of the situations

with and without idealization could motivate students to think more attentively and application of opposite situations could prove to be a useful teaching method. In the teaching of idealizations textbooks, which are essential components of curriculum and education, can accomplish a great mission. Literature review on existing studies reveals that in Turkey textbooks have been analyzed from several dimensions. Textbooks have been assessed many times with respect to scientific content, educational design, book model, information gap, language and teaching, applicability of activities and teachers' views (Ünsal & Güneş, 2004; Ayvacı & Devecioğlu, 2013; Gönen & Kocakaya, 2006; Yıldırım, 2007; Şen & Nakiboğlu, 2014; Karadağ, Dülgeroğlu & Ünsal, 2013; Arslan, Tekbıyık & Ercan, 2012). However in existing studies not any analysis towards idealizations in the textbooks could yet be detected. International literature is also much barren in this topic. In their researches Forjan and Slisko (2014;2017) analyzed three Slovenian high-school physics textbooks with respect to the use of idealizations and simplifications in mechanics, electrics, thermodynamics and waves units. Researchers then detected that in many of the books, idealizations and simplifications were not used correctly. In international literature limited quantity of analyses on the use of idealization in textbooks and lack of any research in national literature on this topic is the driving source of motivation in our research.

In our research the aim is to analyze the content of middle school physics textbooks with respect to the use of idealizations. In parallel with this goal, obtained data have been shared upon analyzing 9, 10, 11 and 12th grade high school physics textbooks.

Method

In this study qualitative research method has been employed and research data have been gathered via document analysis technique which is a frequently employed method in qualitative researches to collect data. Documents provide critical data resources for qualitative researches (Özmen & Karamustafaoğlu, 2019). In this study, Science High School 9, 10, 11 and 12th grade Physics Textbooks (MEB, 2019a; MEB, 2019b; MEB, 2019c; MEB, 2019d) were examined to collect research data. Physics Textbooks taught in Science High Schools were selected on purpose as it is believed that these books are in an advanced level and use of idealization is expected to be higher in percentage.

Obtained data from the research were analyzed via content analysis method. Although there are no preset standard ways for qualitative data analysis, in content analysis, underlying meaning behind the data is exhibited, interpreted and presented to the reader by employing tools such as dimension, code, theme and category (Corbin & Strauss, 2015). In this research

analyzed idealizations were divided into two. Idealizations stated in the unit contents and idealizations stated in the questions. While analyzing the content and questions, data were assessed below three categories namely sufficient, partly sufficient and insufficient. Prior to data analysis, expected idealizations in the content and questions were discussed by three researchers and were then detected after reaching consensus. Detected idealizations were sought after in the content and data related to sufficiency, insufficiency and partly sufficiency. For instance; as Hooke's Law unit in the 11th grade textbook is examined content-relevant idealization is stated such; *"it is valid in conditions when force applied to the coil is proportional with the coil's change of place, when flexibility threshold of the coil is not overrun"*. As definition in the textbook is viewed this explanation has been detected; hence content was deemed to be sufficient: "*Spiral coils; provided that they remain within the flexibility threshold when force is applied their dimensions change, when force is lifted they turn back to their former shape, they are the objects which have been fitted with flexibility quality. According to Hooke's Law F force applied on the coil and change ratio in the coil's dimension x is directly proportional …"*(MEB, 2019c, p. 110). Expansion unit in the 9th grade textbook for the content-related idealization was such; *"It is valid in situations when there is no pressure change; for liquids with cups of which expansion is insignificant, objects' dimensions can be omitted."*. As the textbook definition is read it becomes evident that the need to omit pressure change has not been mentioned and content was deemed to be partly sufficient. Definition stated in the book is such; *"In general the matters of which temperature rises demonstrates a proportional increase in their length, surface area and volume. In tall objects such as string, length change is deemed to be significant whereas in objects such as plates, surface change is deemed to be significant. In objects like prism of which three dimensions are all close to each other, in line with length and surface change, there is a significant change in volume too(Figure 5.5). Expansion of liquids is only recorded as volume change, in cups of which expansion is insignificant expanded liquid rises up in the cup (Figure 5.6). In matters, amount of dimensional change depends on the size of length, surface and volume at the start, level of temperature change and change coefficient specific to the matter."*(MEB, 2019a, p. 135). In the analysis of Impulse unit for the 11th grade, expected idealizations are stated such: "It *is valid in situations when there is momentum change, frictions are omitted, contact duration is not equal to zero. It is then assumed that one of the forces applied on the particle has short-term effect and this force is greater than other forces."* These idealizations were not mentioned in the content of the textbook and the unit was deemed to be insufficient. Given definition in

the textbook is such: *"Multiplying force with application duration is called impulse. Impulse is a vectorial effect and its direction is in the direction of applied force. Its symbol is I."*(MEB, 2019c, p. 124). As units were analyzed by relevant questions, all of the questions below the title of this unit have been examined; units which mentioned idealizations that must be present in all questions were deemed to be sufficient, units which did not mention any of the idealizations in questions were deemed to be insufficient in terms of questions and units in which some questions contained idealizations whereas others omitted idealizations were deemed to be partly-sufficient. For example; as the two questions below the Kinetic Energy of Rolling Objects unit in the 12th grade book are analyzed it is seen that although in some questions required idealizations are stated, they have been omitted in others. One question not stated in idealizations is such; "*A cylindrical object of which mass is 8 kgs, radius is 0,5 m moves forward a horizontal surface with a constant angular speed of 10 rad/s. Compute this cylinder's a) Inertia moment b) Rotation kinetic energy c) Offset kinetic energy ç) Total kinetic energy."*(MEB, 2019d, p. 51). Another example stated in the idealizations is such; *"5 kg mass filled homogenous ball of which radius is r moves forward without sliding on a horizontal plane having insignificant friction. Since speed of mass center is 10 m/s how many Joules is the total kinetic energy of homogenous ball?"*(MEB, 2019d, p. 51). Kinetic Energy of Rolling Objects unit where such examples are stated was deemed to be partly sufficient in terms of questions. Analyses related to the content and questions focused on the units in which idealizations were expected to be dominant. All analyses are presented in the section of tables and findings.

In the research each unit was discussed by three researchers -one academic researcher from Physics Department and two graduate students in Physics Master's program. Discussions dwelled upon expected idealizations and a division was made between effective and ineffective idealizations. In the emergence of any disagreement discussions were continued until reaching consensus and only after reaching a joint agreement, then the next topic was analyzed. Additionally collected data were depicted elaborately by supporting with direct quotations. In order to enhance a research's internal validity it is important that researcher directly manifests the way he attained the results and provide inferences with relevant evidence (Yıldırım& Şimşek, 2008). Thus, it is aimed to ensure validity and reliability of the research. According to Yin (2003) a research should be conducted in a way that helps prospective researchers to reach the same results via applying identical methods. A well-studied documentation of the research is critical to ensure its reliability.

Findings

In this section, data obtained upon the analysis of textbooks with respect to the use of idealization have been presented. For each grade level data are prepared and presented separately as tables. In 9th grade textbook, 11 contexts/concepts have been analyzed and obtained data are as presented in Table 1.

Table 1 Usage Levels of Idealizations in the 9th Grade Textbook

SUBJECTS/CONCEPTS	CONTENT			QUESTİONS		
	Sufficient	Partially Sufficient	İnsufficient	Sufficient	Partially Sufficient	İnsufficient
1. Physics and the Universe			X			
2. Density	X				X	
3. Law of Gravity			X			
4. Newton's Second Law			X			X
5. Gravitational Acceleration and Weight			X		X	
6. Work			X		X	
7. Mechanical Energy		X			X	
8. Elastic Potential Energy			X			X
9. Heat Transfer and Thermal Equilibrium		X			X	
10. Expansion		X			X	
11. Coulomb's Law			X			X

Of all the 11 context/concepts analyzed in the 9. grade textbook, only 1 content in the unit was deemed to be sufficient whilst 7 context/concepts were deemed to be insufficient. Among the questions analyzed in the textbook none of the contexts/concepts were deemed to be sufficient while 6 were categorized as partly sufficient. In the unit, only Density context was deemed to be sufficient and idealizations were described such; *"Under constant temperature and pressure, amount of matter staying constant in unit volume is described as density. Density is symbolized with d and its unit in SI unit system is kg/m^3 ."* (MEB, 2019a, p.41). 5 context/concepts in 10th grade textbook were analyzed and attained data are as shown in Table 2.

Table 2 Usage Levels of Idealizations in the 10th Grade Textbook

SUBJECTS/CONCEPTS	CONTENT			QUESTİONS		
	Sufficient	Partially Sufficient	İnsufficient	Sufficient	Partially Sufficient	İnsufficient
1. Ohm's Law			X		X	
2. Fluid Pressure	X			X		
3. Beam Approach	X					
4. Focal Length in Spherical Mirrors			X			X
5. Image Formation in Lenses			X			X

Among the 5 context/concepts analyzed in 10th grade textbook 2 contents in the unit were deemed to be sufficient whilst 3 contents were deemed to be insufficient. Of all the questions examined in the textbook 1 was deemed to be sufficient, 1 as partly sufficient and 2 as insufficient. In Focal Length of Spherical Mirrors unit, idealizations expected from the content are such;"it is valid in situations when incident rays are close and paraxial to optical axis and when spherical mirror's aperture radius is smaller than mirror's radius" but content is such defined; *"Rays themselves or their extensions reaching parallel to the optical axis convene right in the middle of the peak and central point and this point is named as focal point. Focal point symbol is F. Distance from the peak to the focus is defined as Focal Length and symbolized with f."*(MEB, 2019b, p.227). In the unit, content was deemed as insufficient. In 11th grade textbook 5 context/concepts were analyzed and obtained data are as illustrated in Table 3.

Table 3 Usage Levels of Idealizations in the 11th Grade Textbook

SUBJECTS/CONCEPTS	CONTENT			QUESTİONS		
	Sufficient	Partially Sufficient	İnsufficient	Sufficient	Partially Sufficient	İnsufficient
1. Free Fall Motion	X			X		
2. Hooke's Law	X					X
3. Impuls			X			X
4. Coulomb's Law		X			X	
5. Capacitance in Capacitors			X			X

Of the 5 context/concepts analyzed in 11th grade textbook 2 context/concepts in the unit were deemed to be sufficient while 2 contents deemed as insufficient. 1 question deemed as sufficient in the content was named as sufficient and 3 content questions were categorized as insufficient. One of the units categorized as sufficient in context is the unit of Free Fall Movement. In the context idealizations are such given; *"Movement that an object makes during fall is a regularly-accelerated linear motion without initial speed conducted via vertical direction and g acceleration in -y direction. Near the earth surface since gravitational acceleration is approximately 10 m/s2 result obtained via equation states that irrespective of the mass value of every object, each object left free in frictionless environment would accelerate its speed by 10 m/s every second."*(MEB, 2019c, p.68). In 12th grade textbook 5 context/concepts were analyzed and obtained data can be seen in Table 4.

Table 4 Usage Levels of Idealizations in the 12th Grade Textbook

SUBJECTS/CONCEPTS	CONTENT			QUESTİONS		
	Sufficient	Partially Sufficient	İnsufficient	Sufficient	Partially Sufficient	İnsufficient
1. Kinetic Energy of Rolling Bodies			X		X	
2. Gravitational Force	X			X		
3. Period in the Spring Pendulum			X			X
4. Period in a Simple Pendulum	X			X		
5. Path Difference in Double Slit Interference	X			X		

Of the 5 context/concepts analyzed in 12th grade textbook 3 context/concepts in the content of unit were deemed as sufficient whilst 2 contents were deemed as insufficient. 3 context/concepts deemed as sufficient in the content were also deemed as sufficient in terms of questions too. As for the questions in the other 2 contents, 1 content was deemed to be partly sufficient and 1 content as insufficient. Idealizations expected for Kinetic Energy of Rolling Objects unit is such; “it is valid in situations without sliding, absolute rolling is performed and movement-inhibitor effect of friction is omitted". Yet in the content idealizations were omitted hence the unit was deemed as insufficient. In some of the questions in the unit a few of these idealizations are placed and these questions are deemed to be partly sufficient.

In the textbooks sum of 26 context/concepts in the unit were analyzed as the content and among these contents questions of a total of 23 context/concepts were examined. Questions from Physics Science and Universe, Law of Gravity Mass units in the 9th grade textbook and Ray Approximation in the 10th grade textbook could not be detected; hence these units were excluded from the analysis. Distributions of the analyses related to the examined context/concepts in the textbooks are as shown in Table 5.

Table 5 Distributions of Idealizations in Textbooks

	CONTENT				QUESTİONS			
	Sufficient N (%)	Partially Sufficient N (%)	İnsufficient N (%)	Total	Sufficient N (%)	Partially Sufficient N (%)	İnsufficient N (%)	Total N (%)
9th Grade	1 (%9)	3 (%27)	7 (%64)	11 (%100)	-	6 (%67)	3 (%33)	9 (%100)
10th Grade	2 (%40)	-	3 (%60)	5 (%100)	1 (%25)	1 (%25)	2 (%50)	4 (%100)
11th Grade	2 (%40)	1 (%20)	2 (%40)	5 (%100)	1 (%20)	1 (%20)	3 (%60)	5 (%100)
12th Grade	3 (%60)	-	2 (%40)	5 (%100)	3 (%60)	1 (%20)	1 (%20)	5 (%100)
Grand Total	8 (%31)	4 (%15)	14 (%54)	26 (%100)	5 (%22)	9 (%39)	9 (%39)	23 (%100)

The total sum of context/concept deemed to be sufficient both in terms of content and questions is 5 whereas the number of context/concept deemed to be insufficient both in terms of content and questions is 8. Sufficient questions in the context were deemed to be insufficient and while context/concept number is 1, there are no context/concepts deemed to be sufficient among the insufficient ones in the content.

Results and Discussion

Results of this research conducted to analyze the context of Middle School Physics Textbooks with respect to the use of idealizations are as stated hereinafter;

Data obtained from the 9th grade textbook indicate that with respect to use of idealization, textbook was insufficient in content whilst partly sufficient in questions. In particular, below Physics Science and Universe unit, as physics science is introduced; definition and objective of idealization which is a vital component of physics was omitted, and in many of the units in the book emphasis on idealizations was left unaddressed and this is indeed a major deficiency of the textbook.

Data obtained from the 10th grade textbook indicate that with respect to use of idealization textbook was partly sufficient in content whilst partly insufficient in questions. One of the most striking points in textbooks is that some of the units deemed to be insufficient in content were deemed to be partly sufficient in questions and one of the most clear examples of that is Ohm Law in the 10th Grade. Expected idealizations from the content in this unit are "it is valid in alternating-current resistances and extreme levels of heat, since resistance is subject to change by temperature change of heat can be omitted" and it was detected that these idealizations were not present, hence it was insufficient. In some of the questions of units in the textbook resistance of generator and strings were omitted while in other questions internal resistance of generators was omitted. Also it was seen that in certain questions idealizations were omitted hence questions were deemed to be partly sufficient and this situation could lead the students to face chaos in problem solving.

Data obtained from the 11th grade textbook indicate that with respect to use of idealization textbook was partly sufficient in content whilst insufficient in questions. One of the most noteworthy aspects of the textbook is that at the beginning of Electric and Magnetism unit; "*Elementary particles constituting the matter are, in mathematical sense, accepted as point particle. Therefore loaded objects could be expressed as point load.*" (MEB, 2019c, p. 215) thus emphasis was made on point load. A similar emphasis is detected in 12th grade

textbook Gravitational Force unit too; "*In this unit dependant variables of the gravitational force between point masses will be identified and explained via a mathematical model.*" (MEB, 2019d, p. 68). Emphasizing these statements at the start of each unit is deemed to be quite a positive asset of the book and we believe that in an attempt to grab students' attention it should be emphasized at the beginning of other units too.

Data obtained from the 12th grade textbook indicate that with respect to use of idealization textbook was partly sufficient in content and also in questions. An analysis of the textbooks from the 9th grade till 12th grade reveals that use of idealizations goes up. As the level of grade increases idealizations are mentioned more frequently. Another noteworthy result is that as grade level increased there was improvement in some of the repeated units. For instance; as Hooke's Law unit in the 11th grade textbook is examined content-relevant idealization is stated such; "*it is valid in conditions when force applied to the coil is proportional with the coil's change of place, when flexibility threshold of the coil is not overrun*". Expected idealizations are not stated in the content and in terms of content, unit is deemed to be insufficient. Hooke's Law unit in 11th grade textbook shows that in this book expected idealizations from the unit are not mentioned in the content. In terms of content the unit was deemed to be sufficient and a similar observation holds true for Law of Gravity Mass and Coulomb Law units too. We believe that in the 9th and 10th grade levels when students first encounter science of physics, introduction of idealizations is quite important for them to learn physics.

To sum up high school physics textbooks were deemed to be insufficient with respect to the use of idealizations. A similar finding is echoed in the researches by Forjan and Slisko (2014;2017) too. In their researches it was emphasized that particularly in the problems listed in textbooks idealizations were not emphasized enough. Knowing that idealizations are a major component of learning physics, we believe that this is a situation worthy of attention. Cahyadi and Butler (2004) in their research suggest that use of idealizations plays a vital role in physics teaching. Song et al., (2000) claims that with no correct approach towards idealization it would be hard for students to grasp true meanings of basic concepts, understand the meaning of equations, appreciate the need of a specific experimental procedure in researches and comprehend the difference between daily life experiments and school book experiments. As we all appreciate the role of textbooks in physics teaching it becomes evident that emphasizing idealizations sufficiently in each grade level is quite important. We cannot claim that textbooks all together omit idealizations at all times but it is vital that presented idealizations be

internalized by students and their meaning for physics be truly appreciated. Within that context, specifically in the 9th Grade Physics Science and Universe Unit it is critical to emphasize the place and value of idealizations in the nature of physics and raise awareness towards that end because we observe that even at university level students are not yet aware of the role idealizations play within the nature of physics (Şengören, Çoban & Büyükdede, 2020). In addition, idealizations such as point object, frictionless environment, resistance-free system etc. should be mentioned at the start of units in an interesting and attention-grabbing manner so as to avoid being constantly repetitive. Textbooks should help learners to realize that equations used by students in physics lessons do not necessarily represent the observations they make in daily life and that these equations represent the models developed for idealized systems. In that way textbooks could guide students to be able to hold discussions on equations.

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Fizik Ders Kitaplarında İdealizasyonların Kullanımı

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Özet – İdealizasyonlar fiziğin doğası içerisinde oldukça önemli bir yere sahiptir. Bu araştırmada, ortaöğretim fizik ders kitaplarının içeriğini idealizasyonların kullanımı açısından incelemek amaçlanmıştır. Bu amaç doğrultusunda 9, 10, 11 ve 12. sınıf lise fizik ders kitapları incelenerek elde edilen veriler paylaşılmaktadır. Araştırmada nitel araştırma yöntemi kullanılmış ve veriler doküman inceleme tekniği ile elde edilmiştir. Araştırmanın verileri üç araştırmacı tarafından içerik analizi yöntemi ile analiz edilmiştir. Değerlendirmeler idealizasyonların baskın olarak yer alması gereken konular ile gerçekleştirilmiştir. Bu bağlamda 26 konu/kavram değerlendirilmiş ve araştırma sonucunda ders kitaplarının idealizasyonların kullanımı açısından yetersiz olduğu tespit edilmiştir. İdealizasyonların ders kitaplarında kullanımın sınıf düzeyi arttıkça daha da arttığı çalışmanın önemli sonuçlarından biridir. İdealizasyonların fizik öğrenmenin önemli bir ögesi olduğu göz önüne alındığında bu durumun üzerinde durulmasının gerekli olduğu düşünülmektedir.

Anahtar kelimeler: fizik eğitimi, idealizasyon, ders kitabı

Sorumlu yazar: Harun YILDIZ, Dokuz Eylül Üniversitesi, Buca Eğitim Fakültesi, Matematik ve Fen Bilimleri Eğitimi Bölümü

Genişletilmiş Özet

İdealizasyonların bilimin doğası içerisinde önemli bir yer kapladığı düşünüldüğünde, idealizasyonların öğrenciler tarafından öğrenilmesi ve farkındalıklarının sağlanması oldukça önemlidir. Çünkü idealleştirmenin kendisi fizik öğrenmenin temel bir öğesidir. Ulusal literatürde yer alan çalışmalar incelendiğinde ülkemizde ders kitaplarının birçok açıdan değerlendirildiği görülmektedir ancak bu çalışmalarda ders kitaplarında yer alan idealizasyonlara yönelik herhangi bir incelemeye rastlanmamıştır. Böyle bir incelemenin olmaması çalışmanın temel motivasyon kaynağını oluşturmaktadır. Bu çalışmanın amacı

ortaöğretim fizik ders kitaplarının içeriğini idealizasyonların kullanımı açısından incelemektir. Bu amaç doğrultusunda 9, 10, 11 ve 12. sınıf lise fizik ders kitapları incelenerek elde edilen veriler paylaşılmıştır.

Bu araştırmada baskın olarak nitel araştırma yöntemi kullanılmakla birlikte veriler nicel olarak da ifade edilmiştir. Araştırmanın verileri doküman inceleme tekniği ile elde edilmiştir. Araştırmada Ortaöğretim Fen Lisesi Fizik 9, 10, 11 ve 12. sınıf ders kitapları incelenerek araştırma verileri elde edilmiştir. Araştırmada elde edilen veriler içerik analizi yöntemiyle analiz edilmiştir. Bu araştırmada incelenen idealizasyonlar ünitelerdeki içerikte ve sorularda yer alan idealizasyonlar olarak iki gruba ayrılmıştır. İçerik ve sorular analiz edilirken veriler yeterli, kısmen yeterli ve yetersiz olmak üzere üç kategoriye ayrılarak değerlendirilmiştir. Veriler değerlendirilmeden önce içerik ve sorularda yer alması beklenen idealizasyonlar üç araştırmacı tarafından tartışılıp ortak bir görüş birliğine varılarak belirlenmiştir. Belirlenen idealizasyonlar içerik ve sorularda aranarak yeterli, yetersiz ve kısmen yeterliliğe yönelik veriler elde edilmiştir. Araştırmada her bir konu -fizik eğitimi bölümünde akademisyen olan bir araştırmacı ve fizik eğitimi üzerine yüksek lisansına devam eden iki öğrenci olmak üzere- üç araştırmacı tarafından tartışılmış, fikir ayrılığı durumunda ortak fikir birliğine varılana kadar tartışma devam ettirilmiş ve ortak fikir birliği sağlanmadan bir sonraki konuya geçilmemiştir. Ayrıca elde edilen veriler doğrudan alıntılarla desteklenerek ayrıntılı bir biçimde betimlenmiştir.

Veriler her bir sınıf düzeyi için ayrı ayrı tablolar halinde hazırlanmış ve sunulmuştur. 9. sınıf ders kitabında 11 konu/kavram incelenmiş ve elde edilen veriler Tablo 1.'de paylaşılmıştır. 9. sınıf ders kitabında incelenen 11 konu/kavramdan ünite içerisinde yer alan içerikte yalnızca 1 tanesi yeterli olarak değerlendirilirken 7 konu/kavram yetersiz olarak değerlendirilmiştir. Ders kitabında incelenen sorularda ise yeterli değerlendirilen konu/kavram bulunmazken 6 tanesi kısmen yeterli olarak değerlendirilmiştir. 10. sınıf ders kitabında 5 konu/kavram incelenmiş ve elde edilen veriler Tablo 2.'de paylaşılmıştır. 10. sınıf ders kitabında incelenen 5 konu/kavramdan ünite içerisinde yer alan içerikte 2 içerik yeterli olarak değerlendirilirken 3 içerik yetersiz olarak değerlendirilmiştir. Ders kitabında incelenen sorularda ise 1 yeterli, 1 kısmen yeterli ve 2 yetersiz olarak değerlendirme yapılmıştır. 11. sınıf ders kitabında 5 konu/kavram incelenmiş ve elde edilen veriler Tablo 3.'te paylaşılmıştır. 11. sınıf ders kitabında incelenen 5 konu/kavramdan ünite içerisinde yer alan içerikte 2 konu/kavram yeterli olarak değerlendirilirken 2 içerik yetersiz olarak değerlendirilmiştir. Yeterli olarak değerlendirilen içerikten 1 tanesi sorularda yeterli olarak değerlendirilirken toplamda 3 içerik sorularda yetersiz

olarak değerlendirilmiştir. 12. sınıf ders kitabında 5 konu/kavram incelenmiş ve elde edilen veriler Tablo 4.'te paylaşılmıştır. 12. sınıf ders kitabında incelenen 5 konu/kavramdan ünite içerisinde yer alan içerikte 3 konu/kavram yeterli olarak değerlendirilirken 2 içerik yetersiz olarak değerlendirilmiştir. İçerikte yeterli olarak değerlendirilen 3 konu/kavram aynı zamanda sorularda da yeterli olarak değerlendirilmiştir. Sorularda diğer 2 içerikten 1 içerik kısmen yeterli iken 1 içerik de yetersiz olarak değerlendirilmiştir. Ders kitaplarında ünite içerisinde toplam 26 konu/kavram içerik olarak değerlendirilirken bu içeriklerden toplam 23 konu/kavramın soruları değerlendirilmiştir. 9. sınıf ders kitabında yer alan Fizik Bilimi ve Evren, Kütle Çekim Yasası konuları ile 10. sınıf ders kitabında yer alan Işın Yaklaşımı konusu ile ilgili sorular bulunmadığı için bu konular değerlendirme dışında bırakılmıştır. Ders kitaplarında incelenen konu/kavramlarla ilgili yapılan değerlendirmelerin dağılımları Tablo 5.'te paylaşılmıştır. Hem içerik hem de sorularda yeterli olarak değerlendirilen konu/kavram sayısı 5 iken hem içerik hem de sorularda yetersiz olarak değerlendirilen konu/kavram sayısı 8'dir. İçerikte yeterli sorularda yetersiz olarak değerlendirilen konu/kavram sayısı 1 iken içerikte yetersiz sorularda yeterli olarak değerlendirilen konu/kavram bulunmamaktadır.

Ortaöğretim fizik ders kitaplarının içeriğini idealizasyonların kullanımı açısından incelemek amacıyla yapılan bu çalışma doğrultusunda elde edilen sonuçlar şu şekildedir; 9. sınıf ders kitabından elde edilen veriler incelendiğinde ders kitabı idealizasyonların kullanımı açısından içerikte yetersiz sorularda ise kısmen yeterli görünmektedir. Özellikle Fizik Bilimi ve Evren konu başlığı altında fizik bilimi tanıtılırken fiziğin önemli bir parçası olan idealizasyonların tanımına, amacına ve fizikte kullanımına yer verilmemiş olması, kitap içerisinde yer alan birçok konuda ise yapılması gereken idealizasyonların vurgusunun yapılmaması önemli bir eksiklik olarak görülmüştür. 10. sınıf ders kitabından elde edilen veriler incelendiğinde ders kitabı idealizasyonların kullanımı açısından içerikte kısmen yeterli sorularda ise yetersiz görünmektedir. Ders kitaplarında dikkat çeken önemli noktalardan bir tanesi de içerikte yetersiz olarak değerlendirilen bazı konuların sorularda kısmen yeterli olarak değerlendirilmiş olmasıdır. Bunun önemli örneklerinden bir tanesi de 10. Sınıfta yer alan Ohm yasası konusudur. 11. sınıf ders kitabından elde edilen veriler incelendiğinde ders kitabı idealizasyonların kullanımı açısından içerikte kısmen yeterli sorularda ise yetersiz görünmektedir. Ders kitabında dikkat çeken noktalardan bir tanesi ise Elektrik ve Manyetizma ünitesi ve Kütle Çekim Kuvveti konusu başında noktasal kütle ve noktasal parçacık vurgusunun yapılmış olmasıdır. Bu vurguların kitap içinde bölüm başlarında olması kitap açısından oldukça olumlu bulunmakta ve öğrencilerin dikkatini çekecek şekilde diğer bölüm başlarında da

vurgulanması gerektiğini düşünmekteyiz. 12. sınıf ders kitabından elde edilen veriler incelendiğinde ders kitabı idealizasyonların kullanımı açısından içerik ve sorularda kısmen yeterli görünmektedir. 9. sınıftan 12. sınıfa doğru kitaplar incelendiğinde idealizasyonların kullanım sıklığının arttığı gözlemlenmektedir. İdealizasyonlara sınıf düzeyi arttıkça daha çok yer verilmiştir. Dikkati çeken bir diğer nokta ise sınıf düzeyi arttıkça tekrar eden bazı konulardaki gelişim olmuştur.

Sonuç olarak ders kitapları idealizasyonların kullanımı açısından yetersiz olarak değerlendirilmiştir. İdealizasyonların fizik öğrenmenin önemli bir ögesi olduğu düşünüldüğünde bu durumun üzerinde durulmasının gerekli olduğu düşünülmektedir. Ders kitaplarının fizik öğretimindeki rolü düşünüldüğünde idealizasyonlara her sınıf düzeyinde yeterli ölçüde yer vermek oldukça önemlidir. Ders kitaplarında idealizasyonlardan bahsedilmediğini söyleyemeyiz ama verilen idealizasyonların öğrenci tarafından içselleştirilmesi fizik için ne anlama geldiğinin anlaşılması gerekir. Bu anlamda özellikle 9. Sınıf fizik bilimi ve evren ünitesinin fiziğin doğası içinde idealizasyonların yeri ve önemine yönelik farkındalığı yaratmak açısından önemli olduğunu düşünmekteyiz. Bunun yanında noktasal cisim, sürtünmesiz ortam, dirençsiz sistem vb. idealizasyonlar, sürekli tekrara düşmemek açısından bölüm başlarında ama dikkat ve ilgi çekici olarak verilmelidir. Ders kitapları, öğrencilerin fizik derslerinde kullandıkları denklemlerin her zaman günlük yaşamlarındaki gözlemlerini temsil etmediğini ve bu denklemlerin idealize sistemler için geliştirilen modeller olduklarını anlamalarına yardımcı olmalıdır. Böylece ders kitapları öğrencilere denklemler üzerinde tartışabilecek duruma gelmeleri için öncülük edebilir.

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