ZEYNEP BOYACIOĞLU

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A COMPARATIVE ANALYSIS OF SELECTED BIOLOGY TEXTBOOKS USED IN TURKEY, FOCUSING ON GENETICS CHAPTERS AND THEIR INCLUSION OF NATURE OF SCIENCE

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A Comparative Analysis of Selected Biology Textbooks Used In Turkey, Focusing On Genetics Chapters And Their Inclusion Of Nature Of Science

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Zeynep Boyacıoğlu

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Zeynep Boyacıoğlu

September 2021

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction

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Asst. Prof. Dr. Jennie Farber Lane (Advisor)

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction

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Approval of the Graduate School of Education

Prof. Dr. Orhan Arıkan (Director)

ABSTRACT

A COMPARATIVE ANALYSIS OF SELECTED BIOLOGY TEXTBOOKS USED IN TURKEY, FOCUSING ON GENETICS CHAPTERS AND THEIR INCLUSION OF NATURE OF SCIENCE

Zeynep Boyacıoğlu

MA in Curriculum and Instruction

Advisor: Asst. Prof. Dr. Jennie Farber Lane

October 2021

Textbooks are used widely in classrooms all around the world. Some teachers treat their textbooks as the curriculum and plan their entire teaching according to the textbook. Hence, textbooks should meet the teaching needs of the teachers, while at the same time meeting the learning needs of students. This study aims to compare the genetics-related chapters of four selected biology textbooks widely used in Turkish classrooms: two used by the Ministry of Education (MoNE) and two used for the International Baccalaureate Diploma Programme (IBDP). The textbooks were evaluated according to the criteria published by Turkish Board of Education (TTKB). In addition, the online materials provided with the textbooks and introduction of Nature of Science (NoS) in these textbooks were investigated. The analysis was done on genetics-related chapters, using qualitative content analysis for data collection. The findings of the study showed that all four of the textbooks generally complied with the criteria, however there were some discrepancies. There were some scientific mistakes in both IBDP textbooks. Similarly, there were mistakes in the online materials provided by MoNE textbooks. Finally, the introduction of NoS was analyzed using a modified framework. The findings showed that none of the textbooks had balanced representation of NoS. Overall, none of the textbooks fully complied with the criteria. Thus, teachers and students should be mindful of the findings of this study when using these textbooks for their teaching and learning.

Keywords: *Genetics education, Nature of Science, textbook evaluation*

ÖZET

Türkiye'de kullanılan Seçilmiş Biyoloji Kitaplarının Genetik Üniteleri ve Bilimin Doğa'sına Odaklanan Karşılaştırılmalı Bir İnceleme

Zeynep Boyacıoğlu

Eğitim Programları ve Öğretim Yüksek Lisans Programı

Danışman: Dr. Öğr. Üyesi Jennie Farber Lane

Ekim 2021

Ders kitapları dünya genelinde yaygın olarak kullanılmaktadır. Bazı öğretmenler ders kitaplarını öğretim programı olarak düşünerek ders planlarını kullandıkları ders kitaplarına göre hazırlamaktadır. Dolayısıyla ders kitapları öğretmenlerin ve öğrencilerin ihtiyaçlarına tam olarak uymalıdır. Bu çalışma, Türk sınıflarında kullanılan Milli Eğitim Bakanlığı (MEB) ve Uluslararası Bakalorya Diploma Programı (UBDP) Biyoloji ders kitaplarındaki genetik ile ilgili ünitelerin karşılaştırılmasını amaçlamaktadır. Ders kitapları Talim Terbiye Kurulu Başkanlığı'nın (TTKB) yayınladığı kriterlere göre incelenmiştir. Ayrıca, ders kitapları ile verilen çevrim içi materyaller ve Bilimin Doğası bölümleri de araştırılmıştır. Genetik ile ilgili ünitelerin analizi yapılırken veri toplama yöntemi olarak nitel içerik incelemesi kullanılmıştır. Çalışmanın sonuçlarına göre bütün kitaplar kriterlere genel olarak uyum sağlasa da bazı tutarsızlıklar olduğu gözlemlenmiştir. İki UBDP kitabında da bilimsel hatalar vardır. Aynı şekilde, MEB kitaplarının çevrim içi materyallerinde de hatalar tespit edilmiştir. Son olarak Bilimin Doğası'nın nasıl verildiği incelenirken uyarlanmış edilmiş bir teorik çerçeve kullanılmıştır. Sonuç olarak, hiçbir kitap önerilen kritere tam olarak uygun değildir. Bu nedenle öğretmenler ve öğrenciler ders kitaplarını kullanırken bu çalışmanın sonuçlarını dikkate almalılardır.

Anahtar kelimeler: genetik eğitimi, Bilimin Doğası, ders kitabı incelemesi

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CHAPTER 1: INTRODUCTION

The role of textbooks cannot be overlooked in education; they serve as a guide to both the teachers and the students. Even though the Internet is a dominant source of information used by people around the world – making extensive amounts of information virtually readily available to everyone – many educators still consider textbooks as the primary source of information for lesson planning. Teachers depend on these publications to convey the objectives of the curriculum and plan their teaching (Davey, 2010). They encourage their students to use textbooks as the main resource material for learning.

Thus, choosing which textbook to use is an important decision for education programs. In Turkey, the Ministry of Education (MoNE) curriculum only approves one textbook for each subject area a year. Teachers, therefore, need to use this designated resource which is not the case for those teaching International Baccalaureate Diploma Programme (IBDP) due to the fact that these teachers have many options regarding textbook selection. The choice of the textbook will be very crucial since different textbooks provide varying benefits. Hence, teachers need to be very mindful of their choices.

Background

This study is a thorough textbooks evaluation of the genetics-related chapters in four different textbooks. Thus, in this section how textbooks are used by teachers are introduced. In addition, the reasons why genetics was chosen for this study are explained. Furthermore, Nature of Science (NoS) is an important aspect of science teachings hence an introduction of NoS is also given in this section. Finally, the

criteria by Talim Terbiye Kurulu Başkanlığı [*Turkish Board of Education]* (TTKB) is used as an instrument in this study. The TTKB is the scientific advisory and the decision-making part of MoNE. It has several jobs including:

1. Working on advancing the national education system,
2. Developing new policies and strategies for national education programs,
3. Working with institutes such as higher education institutes and developing educational programs, textbooks, resource books and teaching materials,
4. Evaluating the reports from guidance counselors to verify that the textbooks, educational programs and the educational materials are in line with the educational philosophy, and
5. Making research about the educational system, the educational programs, textbooks and the educational materials (TTKB, 2016).

The subdivision of TTKB that deals with textbooks and educational materials is called "The Board of Textbooks and Educational Materials (Ders Kitapları ve Öğretim Materyalleri Daire Başkanlığı)". This subdivision deals with the evaluation of the textbooks, conforming that the written materials are aligned with the educational philosophy and the standards. In addition, this subdivision is responsible for preparing and renewing textbooks and educational materials (MoNE, 2018a).

Use of Textbooks for Teaching

Historically, textbooks are used as the primary source of teaching in classrooms. In a report published in 1978, 82% of the teachers stated that they used at least one textbook during their teaching (Research Triangle Inst., Durham, NC. Center for Educational Research and Evaluation, 1978). It is also suggested that teachers follow the structure of textbooks during their teaching, planning the lessons according to the flow of the textbook (Kuechle, 1995). A similar study was

conducted in 2014 by interviewing chemistry teachers in Turkey. The results revealed that teachers use the textbook to prepare their lessons and their presentations besides assigning homework to students. In addition, teachers frequently use the textbook to make sure that they are covering the lesson objectives. In other words, Turkish teachers regard the textbook as the curriculum (Akkuş et al., 2014).

As a result of frequent textbook usage in classrooms, the analysis of textbooks is very important. In particular, the decision of which textbook to be used is vitally important. While textbooks are essential for all subject areas, the current study focuses on the role of textbooks in biology teaching, focusing on genetics and the Nature of Science.

Biology is Perceived as Difficult by Students

Biology, which can be seen in every aspect of life, is the science of life. Through a comprehensive understanding of biology, one can explain nearly everything that is happening in one's body and the surrounding environment can be explained. Hence, learning biology and other life sciences is considered as an invaluable aspect of education.

However, biology is perceived as a difficult subject by many students. Tekkaya et al. (2001) suggests that this because students need to integrate previous knowledge with new knowledge. The authors explain that another reason for this perception might be the continuous presentation of new terminology. Learning all these new concepts may be overwhelming for students. Thus, they gravitate towards memorization rather than internalizing the concepts. A well-developed textbook can help students identify and define these concepts. If the textbook explains the

concepts well, students can comprehend the topics rather than just memorizing them (Aycan et al., 2002).

The terminology of biological terms and concepts are often derived from Latin and Greek. Around the world, the words are frequently English translations of Latin words. Therefore, learning biology may even be more challenging for students whose native language is not English. There are two ways of introducing unknown concepts to Turkish students. The first one is inventing new words for the concepts that the students are not familiar with. However, these will still be obscure for the students. Another way is giving new meaning to the already-existing words that the students are familiar with. Nevertheless, this might cause a discrepancy between students' previous knowledge and the intended understanding of the concept (Ayaş, 1993, as cited by Tekkaya, 2001). How these terms are introduced and identified in the textbooks plays an important role in student learning since the textbook is the major source the students have except (Aycan et al., 2002).

Students View Genetics as One of the Most Difficult Topics in Biology

Biology textbooks cover a wide variety of topics, among which there is genetics. Many researchers have learned that genetics is perceived to be one of the most difficult subjects for students to learn. For example, in 1980 Johnstone and Mahmoud interviewed first-year university students and asked them to rate the topics as "easy," "average," and "difficult." Their results revealed that four out of five topics identified as "difficult" by students were related to genetics. A follow-up study was conducted in 1999, showing again that five out of six topics that the students found most difficult were related to genetics (Bahar et al., 1999). Later, similar studies were conducted to see the perception of Turkish students. Tekkaya (2001), showed that three out of five biology topics students perceived as difficult

were directly related to genetics. Similarly, another study conducted in Rize, Turkey, showed that the "genes and chromosomes" topic was the fifth most difficult topic in biology out of 38 topics (Çimer, 2012).

Genetics in Turkey's National and International Education Programs

Genetics is a very broad subject and is a part of many biological topics. The current study focused on chapters and included units that are explicitly state the word genetics in their title. Furthermore, the study is limited to genetics included in grades 10, 11, and 12. Information about the curriculum related to these grade levels is provided below.

Most schools in Turkey follow the curriculum developed by its MoNE. In their curriculum, genetics-related chapters are taught in two years in secondary education; in Grade 10 and Grade 12. In Grade 10, the "General Principles of Inheritance" is taught and in Grade 12, the "From Genes to Proteins" unit is taught (MoNE, 2018b).

There are a number of schools that also follow an international program called the IBDP. This program aims to develop internationally-minded, students during their last two years of secondary school. The IBDP is concerned with the whole education of the student rather than just academic. Hence, the students are expected to complete and Extended Essay, Theory of Knowledge courses and Creativity, Action, Service (CAS) hours in addition to their academic endeavors. Furthermore, IBDP students study six subjects in two years. The students can decide which subjects they wish to study according to their interests. At the end of the two years, the students would have completed an intercultural holistic education. The IBDP aims all their students to be life-long learners and inquirers (IBO, 2015).

Regarding genetics in the IBDP curriculum, there are four genetics-related chapters: Chapter 3: Genetics; Chapter 7: Nucleic Acids, Chapter 10: Genetics and Evolution and Option B: Biotechnology and Bioinformatics. Chapter 3 is a part of the Core topics, meaning that all the students study this topic. Chapters 7 and 10 are for the students who are taking Higher Level Biology only. Finally, Option B is one of the four options the students can choose from. In other words, not all the students will study Option B, regardless of the level the students chose. IBDP is a two-year program; the teachers can change the order of the topics however they wish. So it is not possible to deduce when the students will learn about genetics in their secondary education (IBO,2014).

Nature of Science

Another very important context in biology teaching is the Nature of Science (NoS) and scientific literacy. It is the ability of students to assess the quality of scientific information presented by scientists, media or their textbooks (Shaffer et al., 2019). It is very important for science educators to instruct NoS and scientific literacy to their students, since they are the fundamental parts of science education (Lee, 2007).

As explained above, genetics is considered as one of the most difficult subjects. It is shown that students have difficulties conceptualizing genetics concepts (Kim & Irving, 2010). In addition, genetics topics can be considered as the “ideal” topic for investigating NoS as the work of Mendel is generally misrepresented; the other scientists working on heredity at the same time are often not mentioned, the work of Mendel is generally oversimplified and the fact that his findings were an exceptional case are sometimes overlooked (Campanile et al., 2015; Williams & Rudge, 2016). Thus, genetics topics are used commonly when NoS is investigated.

Problem

Publishers around the world produce books on biology. Educational institutions need to decide which ones to use. A well-developed textbook can help students master terminology, address misconceptions, and convey the Nature of Science while also helping students review what they have learned (Akkuş et al., 2014). Moreover, textbook selection is important to help students comprehend challenging biology topics such as genetics.

In Turkey, TTKB is responsible for textbook selection. They have released a set of criteria that each textbook needs to abide by. For a textbook to be approved and used nationwide in Turkey, it needs to match with these criteria. This criterion is very comprehensive. It analyses textbooks according to their suitability of the constitution, the scientific content, the extent to which the textbook meets the educational program scope and the objectives, and the extent to which the visual design supports learning (TTKB, 2018). This criterion covers a variety of limitations for the textbooks; ranging from ensuring that males and females are reasonably equally represented in the examples to how important messages should be highlighted (TTKB, 2018).

Many schools in Turkey also have international education programs as part of learning experiences for their students. One of these programs is the IBDP which aims to have internationally-minded learners at the end of a two-year study. Several companies produce biology textbooks for IDBP. Unlike the Turkish educational system, IBDP teachers do not have review criteria for selecting which textbook to use in biology. Therefore, it is important to examine the biology textbooks used by the IBDP to determine if they comply with the criteria outlined by the TTKB. Moreover, despite the rigor of the TTKB's evaluation, the criteria do not assess the

accuracy of genetics topics, especially in consideration of the nature of science. Therefore, textbooks used by both national and international education programs in Turkey would benefit from an examination of the genetics and related scientific thinking content of their textbooks.

Purpose

This study used qualitative content analysis to compare and contrast how four textbooks (two MoNE textbooks and two IBDP textbooks) covered genetics-related topics. The TTKB textbook evaluation criteria published by the MoNE was used to evaluate all the books. The criteria were applied to the IBDP textbooks because they are used in Turkish classrooms, in MoNE accredited schools.

In addition to the printed content, this study also investigated the supplemental online materials provided by the textbook company. Finally, NoS aspects of the books were examined according to the framework created by Chiappetta in 1991 and that was later modified to be used for biology textbooks by Lee in 2007.

Research Questions

This study aims to answer the following questions:

1. How do the genetics-related chapters in two MoNE and two IBDP textbooks align with the TTKB criteria?
2. How do the supplemental online materials align with the TTKB criteria?
3. To what extent is the Nature of Science addressed in these genetics-related chapters?

Significance

The findings of this study highlighted similarities and differences in genetics education in selected biology textbooks; this review was conducted in the light of

their compliance with the TTKB criteria. Since textbooks are widely used as instructional materials (Davey, 2010), this study will largely enable teachers who are struggling to decide which textbooks they should follow to determine that all the aspects of the curriculum are covered while students get the most benefit from the textbook.

Science is ever-changing. Especially after the Human Genome Project, the lives students of today could be substantially different from previous generations. Nature of Science and scientific literacy hence becomes more important than ever. Students learning about genetics today might have to face decisions about their personal genetics. It is the duty of the teacher and the textbooks to determine that the students can think scientifically and are equipped enough to make educated decisions later on in their lives (Kung & Gelbart, 2012). Thus, this study also investigates how NoS is introduced in different textbooks. As stated earlier, it is becoming more and more important for students to be scientifically literate. The world they are living in is changing rapidly with new scientific developments. In the future, they will be expected to make decisions about their lives and their health. Hence, it is especially important for them to learn how to understand and interpret scientific data. With the help learning NoS, the students can be more equipped in making these kinds of decisions in the future. Thus, NoS is also included in this study.

Limitations

There are several limitations of this study. First of all, this study involved only genetics-related chapters. Hence only some parts of the textbooks were evaluated. In addition, only textbooks implementing two curricula were evaluated. The findings of this study are limited to these two curricula and only one topic.

Another limitation is the fact that the researcher is competent in Biology. The textbooks were analyzed according to their content. The researcher is already familiar with the concepts. However, the students will be learning about these topics for the first time. Thus, the researcher might disregard some ambiguity in the textbooks.

Finally, this study had time constraints as the curricula and the textbooks would change over time. Even though this study can work as a guide for publishers for future textbooks, the textbook and the curricula used in this study will become unrelated as there are new textbooks and updated curricula.

Definition of Key Terms

International Baccalaureate Diploma Programme (IBDP): IBDP is an externally assessed diploma program. Which both aims provide students (aged between 16-19) with an international education so that they can understand the complexities of the world around them better; and provide them with the skills so that the students can change the world for the better as well (IBO, 2015).

Nature of Science (NoS): Nature of Science (NoS) is the comprehensive description explaining what science is, how science works, how scientists work and how science affects and is affected by the environment. In the education context, NOS also includes how science should be involved in teaching. The epistemological aspect of science is also a concern of NOS. In other words, NOS is how one perceives science (Lee, 2007).

Scientific literacy: Scientific literacy can be defined as the ability to use science and scientific knowledge when evaluating the information provided by the scientists and the news. In addition, scientific literacy encompasses the ability to use

knowledge to draw scientific conclusions and comprehend the natural world entirely (Shaffer et al., 2019).

Talim Terbiye Kurulu Başkanlığı (Turkish Board of Education [TTKB]): TTKB is the scientific advisory committee of the Turkish Ministry of Education. Their responsibilities include, but are not limited to, working to improve the educational system, taking part in the preparation of educational materials and curricula, evaluating the textbooks and teaching materials and conducting research Ministry of National Education [MoNE], 2012).

List of Acronyms

IBDP: International Baccalaureate Diploma Programme

MoNE: Ministry of National Education

NoS: Nature of Science

TTKB: Turkish Board of Education

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

This study aims to evaluate four textbooks based on the criteria published by TTKB. This evaluation was limited to textbooks used in upper secondary classes in Turkey. Two of these textbooks are used in biology classes that follow the biology curriculum of the MoNE and two are used in biology classes within the IBDP. All the chapters that were completely dedicated to genetics were investigated in this study. In addition, the online materials provided with the textbooks were also evaluated as a part of the study. Finally, NoS aspects of the textbooks were also analyzed.

The purpose of this chapter is to introduce concepts related to the study. The chapter includes why genetics was chosen as the subject of interest, the role of the TTKB, how textbooks are used, online materials and NoS. Furthermore, the presentation of genetics in the two different curricula was explained. Lastly, prior studies about textbooks evaluation were introduced.

Use of Textbooks in Teaching

Textbooks are an invaluable teaching and learning tool. A UNESCO report published in 2016 revealed that not all students have access to textbooks despite the undisputable increase in the success of the students if they have access to textbooks. There is also considerable increase even if only several students have access to textbooks in a classroom due to motivation and peer learning. However, as the ratio of textbook-to-student decreases, success of the students also decreases. The report

suggests that a motivated and well-prepared teacher can create wonders in student learning with the help of a well-designed textbook (UNESCO, 2016).

The role of textbooks in teaching cannot be overlooked. There are several studies outlining how teachers use textbooks in their classrooms. Besides being regarded as the main sources of information while teaching. In addition, textbooks limit the information provided according to the requirements of the curricula (Rottensteiner, 2010). They also help teachers plan their teaching according to the curricula (Kete et al., 2012).

A study conducted by Uzuntiryaki and Boz (2006), analyzed how much preservice physics, chemistry and biology teachers used the textbooks. The results of this study showed that only 20.8% of the teachers used the textbooks all the time, whereas 50.4% rarely used the textbooks. Most of the teachers used textbooks as the curriculum and material preparation. Aykus et al. (2004). performed a similar study that revealed how Turkish Chemistry teachers used textbooks in their classrooms. The results demonstrated that most of the teachers used textbooks during lesson planning, material preparation and assigning homework. However, they did not use textbooks to refresh their knowledge since they thought that the information in the textbooks was not comprehensive enough and they were confident in their subject area knowledge. The results of these studies showed that teachers treated textbooks as the curriculum.

Textbook Analysis Studies in Turkey

Over the years, there have been several textbook analysis studies conducted in Turkey. Notably, after the United States of America, worldwide Turkey has published the most studies about textbooks between 2000 and 2018 (Vojíř & Rusek, 2019). The studies range from primary school to high school textbooks, including

Turkish as a Foreign Language textbooks. Atıcı and Keskin Samancı (2007) analyzed biology topics in science textbooks used in Grade 6, 7 and 8. In addition, they interviewed 136 pre-service teachers and 32 in-service teachers. Their results showed that the textbooks lacked scientific information. Furthermore, both the texts and the figures would lead to misconceptions.

In another study, Arslan and Özpınar (2009) analyzed Grade 6 Mathematics textbooks. Their results showed that although the textbooks were aligned with the curriculum and the objectives, the real-life connections, examples and activities were more advanced than the students' developmental stage.

The readability of the reading texts in Grade 9 Biology textbooks were evaluated with five different readability indexes in a study by Köse (2009), the results of which showed that the reading texts about cells in Grade 9 textbooks were easy to understand and the readability of the texts was determined as "easy". When the texts were evaluated using the Cloze test method, it was shown that the texts were only comprehensible when read with a teacher. However, since the teacher was with the students to guide them during their learning, the readability of the texts can be considered acceptable (Köse, 2009).

In a more recent study, Gündüz et al. (2016) analyzed Grade 10 Biology textbooks regarding scientific concepts. It was revealed that in all three units of the textbook and in the end-of-chapter questions, there were scientific mistakes. It was suggested that the textbooks approved by MoNE should be proofread by experts.

Direkçi et al. (2018) analyzed middle school Turkish textbooks and the Turkish Language curriculum with regard to digital literacy skills. Their results showed that there were no activities or objectives supporting digital literacy in none of the textbooks.

There are also several theses investigating textbooks analysis. İnanç Gök (2012) compared one MoNE textbook and one IBDP textbook about cellular respiration and photosynthesis units. The results showed that the details in the MoNE textbooks were not adequate to the students' level, while also lacking some major themes. Moreover, the use of technology was not as prominent as the IBDP textbook. On the other hand, the thesis showed that there were many student-centered activities, experiments and real-life connections in the MoNE textbook.

Ödün (2013) also compared the ecology units of four MoNE, one IBDP and one IGCSE textbook. The results showed that MoNE textbooks had several advantages over the IBDP and IGCSE textbooks. For example, MoNE textbooks had numerous real-life examples and connections to other disciplines. Furthermore, the language of MoNE textbooks was perceived as more student friendly. Lastly, student learning was supported by many activities and questions in the MoNE textbooks.

Similarly, Yıldız (2013) investigated the use of history of science in high school biology textbooks. She found that even though there was history of science abstracts in the textbooks, they were not comprehensive.

Finally, in 2017, two Grade 9 Biology textbooks, one private publishing and one MoNE, were evaluated according to the criteria published by TTKB. The results revealed that the private publishing textbooks better suited the TTKB criteria than the MoNE textbook. Both textbooks could be designed better. In addition, in MoNE textbook, not all the objectives were met as some were covered only partially (Erten, 2017).

Importance of Online Materials

We live in an age where there are almost unlimited online resources available for everyone. The way information can be accessed has changed dramatically over

the years. Nowadays, the students can be considered as “digital natives” and they are extremely skilled at using technology and accessing information online. Thus, teachers are not the only source of knowledge in the classrooms. Even accessing the information themselves is not enough for the students, they expect to have an interactive and collaborative learning environment where they can be assumed as co-creators (Knight, 2015).

Furthermore, due to the unexpected Covid-19 Pandemic, the need for online materials has increased beyond imagination. Teachers and students all around the globe had to adjust to a new way of learning. One of the problems faced by teachers was the absence of interactive teaching materials (Ferri et al., 2020). Hence, the online materials provided with the textbooks have become much more important, even a conclusive factor in deciding which textbook to use.

Nature of Science

Nature of Science (NoS) can be defined as the “the epistemology of science” (Lederman, 2007). In other words, NoS can be interpreted as a way of understanding science. Science is everchanging; hence, it is not feasible to have only one definition of NoS. Fortunately, there are four widely accepted major themes of NoS, illustrating the intent of texts, widely accepted by researchers. The four themes were first presented by Chiappetta, et al. in 1991, later modified by Lee in 2007. The four themes are explained below:

1. “Science as a way of knowing”:

The intent of the text is to convey scientific knowledge directly. Students might be asked to recall information, facts, concepts…

2. “Science as a way of investigation”:

The intent of the text is to encourage students to think about the scientific method. This theme of NoS is highly involved in hands-on experience of students, making them continue with experiments, or analyze, record and infer data. It is vital to note that if the question asked in the text is immediately answered, that text should be considered as a part of the first theme even if the question is about the scientific method and/or data analysis.

3. "Science as a body of knowledge":

The intent of the text is to show the students how science progresses and the scientists work. In short, the students are demonstrated how science works in real life.

4. "Interaction of science with technology and society" (Lee, 2007, p.167-170).:

The intent of the text is to show science, technology and society are interlaced with each other. There is an emphasis on how science and technology are influenced by each other as well as how society is indefinitely connected to scientific endeavors.

When looking for the introduction of NoS in textbooks, the researchers were encouraged to consider for the balance of these four themes. The framework which was used in the current study was present in the dissertation by Lee (2007).

Genetics Identified as a Difficult Topic

In a 2021 study, it is shown that Turkish students fear biology mostly because their fear of failure, not understanding the topics and not liking biological topics (Ozaslan, 2021). In particular, within biology students report difficulties the science that deals with DNA or genetics (Winchester, 2020). Even though it is a relatively new area (being investigated for less than two centuries), the effects of Genes and

Chromosomes on humans are undeniable due to the fact that it has application on almost every aspect of life; ranging from agriculture to medicine and beauty (Snustad & Simmons, 2012). Considering its importance, it is very unavoidable to teach this topic to high school students so that they can be familiar with the topic.

Unfortunately, evidence shows that students have difficulties in this subject. A preliminary study asked 167 freshmen university students to label the topics in high school biology curriculum as Easy, Average, Difficult or Never Studied. The results of this study showed that Genetics was the third most difficult topic, as perceived by students (Johnstone, 1980). A similar study was conducted in Turkey by Tekkaya (2001) who investigated the biological concepts high school students thought were the most difficult. Therefore, the researchers examined the high school biology curriculum and created a list of Biology concepts (in total 30 concepts). Later, they asked 368 high school students from different high schools to indicate the difficulty level of these topics and their reasons. The results showed that Turkish high school students thought that Genetics was the due to the fact that the genetic terms (such as allele, chromosome, chromatid) were too abstract and thus confusing (Tekkaya, 2001).

Tekkaya's 2001 findings were supported by a later study conducted in Rize, Turkey. In this study, Çimer (2012) investigated the reasons why biology learning was difficult. He conducted a self-reporting questionnaire to 207 Grade 11 students from nine classes in seven different high schools. He provided the students with a list of 38 Biological topics and asked them to indicate the five most difficult ones along with their reasons. The results showed that Genes and Chromosomes was the fifth most difficult topic, according to the students (Çimer, 2012).

Importance of Genetics Education

Over the last few years, there has been tremendous advance in the field of genetics; similarly personal genomics is also gaining attention. Personal DNA sequencing is becoming more common every year, revealing information that we did not have access before, such as having an increased risk of a disease. With the possibilities being virtually limitless, it is very important for high school students to have a comprehensive understanding of genetics, as they are the ones that will live in this "future" (Kung & Gelbart, 2012), marking genetics literacy one of the most important 21st Century skills (Aivelo & Uitto, 2021).

Included among these skills is systems thinking. Comprehending biological concepts in general and genetics in particular enhances students' systems thinking skills. Systems thinking can be a beneficial tool for helping students elevate their fears of biology. With the help of systems thinking, the students will be able to understand the "big picture" of biological systems (Gilissen et al., 2020). Systems thinking can help students apprentice that the biological topics are connected to each other, helping the students make better sense of what are learning (Moore-Anderson, 2021).

Despite the importance of and strategies to support learning of genetics, public understanding of genetics is shown to be very low. A 2010 study showed that although the participants had theoretical genetics knowledge, their understanding of genetics testing and their perceived knowledge of genetics were much lower (Haga et al., 2010). Thus, ensuring students graduate high school with an understanding of genetics, including in consideration of the nature of science, will benefit society and environmental sustainability.

Conclusion

Textbooks are an essential part of teaching. Textbooks need to be free of mistakes, supporting the teaching and learning environment in classrooms. Hence, a detailed textbooks analysis study is needed.

Genetics is one of the most influential topics in Biology. In the advancing biological and technological world, it is essential that future adults have a comprehensive understanding of genetics. However, many studies show that most of the students have trouble comprehending genetics-related topics in school. Hence, it is up to the teachers should enable their students to be competent about genetics when they graduate.

Given the importance of genetics in the near future, it is essential that the students should have at least a base level understanding of genetics (Kung et al., 2012). Thus, it is crucial that they learn the fundamentals of genetics in high schools. However, as stated earlier, textbooks are treated as the curriculum in many classrooms (Kete et al., 2012). This shows that there is an urgent need for analyzing genetics-related chapters in textbooks used in Turkey. Even though there are many studies done to analyze Turkish textbooks, there are no studies known by the researcher that evaluated the genetics-related chapters. Hence, this study can serve to fill in this gap in the Turkish education literature to help future generations, while also helping today's teachers and students of today.

CHAPTER 3: METHOD

Introduction

Chapter 3 explains the methods that were used to address the research questions of this study. Below are details about the strategy for evaluating the textbooks' contents, including online materials and how they address the nature of science. The researcher will occasionally speak in first person to convey her own experience regarding the instrumentalization and data collection.

Research Design

This study involved a content analysis of the textbooks used by biology classrooms following the curriculum of the MoNE and those used by classrooms following the IBDP curricula. The textbooks and their online materials were investigated according to the criteria published by the TTKB. In addition, the introduction of NoS in the textbooks were evaluated according to the framework modified by Lee (2007).

Content analysis is defined as "an unobtrusive technique that allows the researchers to analyze relatively unstructured data in view of the meaning, symbolic qualities, and expressive contents…" (Krippendorff, 2013, p. 49). It is important to note that content analysis is a reliable and replicable scientific tool that can either be qualitative or quantitative.

This study uses qualitative content analysis (QCA). In essence, QCA is deciphering the meaning of a qualitative data systematically (Schreier, 2013, p.1). This is done by assigning the part of the material being studied to categories determined by the researcher. Some of the categories were based on standards, terms

and concepts that have meanings that may be similarly understood by the members from the same community or who share a common culture (Schreier, 2013, p.1-2). With science textbooks, there are certain established concepts that are accepted by the scientific community.

Although some parts of the textbooks are standardized (for example the scientific knowledge), most parts of this study involve interpreting the hidden meanings in the texts. Hence, this study utilizes QCA. Despite the norms of scientific understandings and processes, there are concepts, ideas, and processes that may be debated or conflicted. In other words, some texts will not have standardized meanings that may require deeper explanations and judgments. QCA relies on the fact that the meanings of the written materials are not explicitly given in the text, but the readers should construct those meaning themselves (Schreier, 2013, p.2).

The study consisted of three parts. First, the chapters in the textbooks were read thoroughly and then were compared against the criteria published by TTKB. Second, the online materials provided with the textbooks were evaluated. Finally, the reading texts and NoS sections of the textbooks were investigated to look for the introduction of Nature of Science. To this extent, the framework created by Chiappetta in 1991 and modified by Lee in 2007 was used.

Context

Biology is a subject that is introduced in Grade 9 in Turkey, after taking general science classes in middle school. At the time when this study was conducted in 2019, all Turkish students need to take Biology course in Grades 9 and 10. After this, the students have the option to choose if they wish to continue in a Mathematics-Science route, Mathematics-Turkish route, Turkish- Social Sciences route or Foreign Languages route. The students continue to learn take Biology course

only if they continue in the Mathematics - Science route. In other words, Biology is only mandatory in the first two years of high school education in Turkey.

All the schools should follow the MoNE curriculum for the students to graduate high school. However, some schools can choose to follow other international curricula in addition to MoNE curriculum, one of which is IBDP. Since it is one of the most widely followed international curriculum in Turkey, it is added to the study.

The genetics topics were chosen for investigation since it is a topic regarded as difficult by students both in Turkey and in other parts of the world (Tekkaya et al., 2001). In addition, the researcher has a BS and MSc in Molecular Biology and Genetics, thus she is competent in genetics and she can be considered as an expert for evaluating the scientific content of the textbooks.

Sampling

For this study, four textbooks were purposefully selected for the analysis. Of these books, two were MoNE books and two were IBDP books. The books chosen for the MoNE curriculum are the official books assigned by the ministry. They are the main instructional tool in classrooms following MoNE curriculum. Every academic year, TTKB evaluates and approves textbooks for each subject. There can be several textbooks approved for the subject from different publishers. For this study, the researcher chose the textbooks that are published by the government and provided free of charge to schools and students (MoNE, 2016). For IBDP classrooms, schools can select which books they will use. There are several textbooks they choose. The decision is ultimately made by the departments and the opinions of the teachers. Based on visits and internships in Turkish schools and on conversations with Turkish IBDP teachers, two IBDP books were selected for this

study (Table 1). The Oxford University Press textbook is the one used in Bilkent Laboratory and International School (BLIS). This is the first school to get IBDP accreditation in Ankara. The other textbook chosen is the Cambridge University Press textbook, which is the book used in TED Ankara College. It is the second school to get IBO accreditation in Ankara and serves a large population of IBDP students.

It is important to note that the MoNE textbooks are used for only one grade thus, MoNE textbooks are two different levels of the same publications. One of the textbooks is used in grade 10 and the other is used in grade 12. On the other hand, the IBDP textbooks are used for the entire two-year programme. Hence, the two textbooks are separate entities by different publishers. In one sense, three textbooks were compared: One provided by MoNE and two used in IBDP. Nonetheless, the researcher treated the MoNE publication as two separate textbooks since they cover different topics in genetics.

In addition, genetics is a very broad area of biology; it is not possible to discuss majority of the biological topics without mentioning genetics. Hence, only the chapters that solely focus on genetics as a major concept were investigated in this study. Thus, in all four of the textbooks, the chapters where the whole chapters were dedicated to genetics were chosen for this study. In each of these books, the table of contents was reviewed to identify chapters related to genetics. The textbooks and chapters used in this study are given in Table 1.

In MoNE, the textbook for each grade level has one chapter dedicated to genetics. For the Grade 10 textbook, the focus was on Chapter 2: General Principles of Inheritance and for the Grade 12 textbook, the focus was on Chapter 1: From Genes to Proteins. There were three chapters in both of IBDP textbooks dedicated to

genetics. Although the textbooks are produced by different publishing companies, the number and titles of the chapters are the same as they use the titles identified in the IBDP programme guide.

Table 1

The Textbooks and the Chapters Under Investigation

Curriculum	Textbook Title	Chapter(s)	Publisher	ISBN
MoNE	Grade 10	CH2: Kalıtımın Genel İlkeleri	Devlet Kitapları	978-975-11-4647-2
MoNE	Grade 12	CH1: Genden Proteine	Devlet Kitapları	978-975-11-4648-9
IBDP	Biology for the IB Diploma	CH3: Genetics CH7: Nucleic Acids (AHL) CH10: Genetics and Evolution	Cambridge University Press	978-1-107-6560-0
IBDP	Biology Course Companion	CH3: Genetics CH7: Nucleic Acids (AHL) CH10: Genetics and Evolution	Oxford University Press	978-0-19-8392211-8

Instrumentation

A different instrument was used for each part of the study. For the first part, the TTKB criteria for proposed textbooks were used since every official textbook published in Turkey should follow these criteria. The TTKB is the scientific advisory and decision-making body of the MoNE. TTKB is responsible for many jobs,

including improving the educational system, giving the order to prepare the textbooks, doing research on textbooks, observing and evaluating educational progressions both nationally and internationally. Detailed information about TTKB is given in Chapter 1. One of their duties is to publish criteria for new textbooks and e-contents to be used every school year. The criteria are very detailed, evaluating the textbooks as a whole. There are regulations on the content that should be presented in the textbooks, how the figure and formatting should be. In addition, there are also criteria for how different types of questions should be written. Finally, there are also criteria looking at the subtext of the content, making sure that the textbooks are in line with the societal values, there are no discriminations against any group or no advertisements. When new textbooks will be published, TTKB sends the online versions of these textbooks to panelists to evaluate the textbooks. After the initial evaluations, eight panelists come together and discuss if the textbooks meet the criteria used in this study. This is the reason why this instrument was chosen. To ensure reliability, two other researchers evaluated sections from the textbooks to make sure that their findings are in line with my findings. There were no discrepancies between the three evaluations. The same criteria were used to evaluate all four of the textbooks, including the two IBDP textbooks since they are also being used in Turkish classrooms, so they should also follow the rules set out by the Ministry of Education.

For the second part of the study, the online materials provided with the textbooks were evaluated. To this end, all the online materials were investigated using the same criteria as TTKB published the criteria for both textbooks and e-contents. All the online materials provided with the textbooks were read thoroughly,

the questions were solved and the answers were checked. Screenshots were taken and the findings are reported in MS PowerPoint presentations.

A separate tool was used for the last part of the study, which involved assessing the NoS of the textbooks. NoS means, generally, an understanding of science. In other words, NOS can be explained as to how science functions and how it is related to every aspect of life (Cetin et al., 2016). To this end, the framework modified by Lee (2007) was used in the current study. In this framework, the evaluated unit was categorized into one of the four NOS categories. These four themes are as below (details of these four themes are explained in Chapter 2):

- Presents knowledge produced by science and the nature of this knowledge (Lee, 2007, p. 167)
- Engages students in investigations, science process skill, and reasoning (Lee, 2007, p. 167)
- Illustrates thinking, work of scientists, and scientific enterprise (Lee, 2007, p. 168)
- Shows interaction among science, technology, and society, and the social construction of knowledge (Lee, 2007, p. 169)

Reliability of the Frameworks

To ensure that the use of the TTKB framework was reliable, the researcher first analyzed selected units from the textbooks. Then two other researchers were invited to review these same sections. Through this inter-rater reliability process, the comparison showed that all three researchers had similar evaluations of the textbooks.

Regarding the NoS framework, Lee (2007) took several steps to ensure its validity. While developing the framework, Lee used the triangulation method. Two

researchers, with one having more experience with these types of investigations. Later, their findings were compared. To ensure reliability, 17 Practice Assessment Analysis provided with the instrument were used. This consisted of 62 practice units together with their classifications. In the current study, the researcher used these practice units to prepare herself for the analysis. After conducting the practice exercises, she compared with the results in the framework to see if there are any discrepancies. The comparison revealed that the classification done by the researcher and the answers provided in the framework matched.

Method of Data Collection and Analysis

All the chapters related to genetics in four different textbooks were evaluated in three parts in this study. In the first part, the contents of the textbooks were evaluated according to the criteria published by TTKB. For the second part, the online materials provided with the textbooks were evaluated. Finally, for the last part of this study, the introduction of NoS in the textbooks was evaluated according to the criteria modified by Lee in 2007. The details of these parts are explained below.

Evaluation of Textbooks' Contents

At the beginning of the study, a framework was constructed to follow for all the textbooks. The textbooks were thoroughly evaluated for this study. The evaluation is done in three stages: *before reading, while reading* and *after reading*. Table 2 shows the review process used for this study based on the TTKB framework. Further details about the process are provided below. A detailed checklist of the criteria is provided in Appendix A. After all the investigations were over, all the data collected were logged in a detailed table created in Microsoft Excel. The researcher kept the details and her observations about the textbooks in another worksheet in

Microsoft Excel. The findings were compared with each other. The explanations and the interpretations of the data are given in Chapter 4 and Chapter 5, respectively.

Table 2

Focus of Textbook Sections Used During the Review Process

Before Reading	While Reading	After Reading
Cover	The Text	Questions
Book features	Examples	Experiments/Activities
Links to curriculum	Terminology	Figures
	Resources	Design

Before Reading

The evaluation of the textbooks started with the evaluation of the textbooks' covers. The cover of the book was investigated according to the criteria published by TTKB. The cover pages were evaluated to see if the cover is related to biology or not. In addition, the cover was investigated if the word "Biology" is written, if the grade was written or if there were credentials of the authors.

Later, the features of the textbooks were investigated. The dictionaries, bibliographies, and "How to Use" pages of the textbooks were evaluated. Furthermore, TTKB Criteria specifies that a textbook should not contain information about the authors and the publishers. Hence, the books were investigated to see they have any information about the authors or the publishers.

Lastly, the textbooks' links to the curriculum were investigated by calculating the ratios of the chapters in the curricula and the textbooks as followed. The proposed percentages of each chapter are provided in the MoNE curriculum.

Therefore, the percentage of each chapter in the textbook was calculated by dividing the total number of pages by the number of pages each chapter has and then multiplying by 100. For the IBDP, the recommended teaching hours are provided in the Biology Guide. Teaching hours were converted into percentages by dividing the total teaching hours (without options) by the recommended teaching hours of each chapter then multiplying with 100. As with the MoNE chapters, the percentages of the chapters in the textbooks were calculated. It should be noted that for the Oxford University Press textbook, the Option pages were not taken into consideration in the total page number of the textbooks as different students choose different options to study and the guide does not expect any student to study all the options. Hence, the number of pages for Core and Additional Higher Level chapters were used as the total number of pages in the calculations. No adaptations were needed to Cambridge University Press textbook since the Option pages are not printed in this textbook.

While Reading

A comprehensive investigation of the content of the textbooks was done by reading the texts of the books thoroughly. Any missing, or wrong information was identified and recorded. Moreover, the chapters were checked if they satisfy all the learning objectives in their respective curricula. According to TTKB, there should not be any advertisements in the textbooks, so the researchers looked if there were any advertisements in the texts. In addition, TTKB suggests that the chapters should follow a simple to advanced explanations with clear definitions and connections to other subjects. This was also inspected. Finally, there are root values specified in the TTKB Criteria that should be implied in the text, but not written directly. The chapters were evaluated for the implications of these root values.

The examples given in the chapters were also under investigation for this study. Male/female representations and the social scenarios of these representations were studied. Furthermore, the examples were reviewed to see they have discriminating qualities for any member of the society.

Terminology is a very important part of biology education, and it is a big part of any textbook. To this end, the biological terminology was assessed if they were written and used correctly, as well as checking if appropriate terminology was used when needed.

Final investigation of the "While Reading" section was the investigation of resources of the chapters. The chapters were examined to see there were resources available and if so, were these resources scientific.

After Reading

The final aspect of the first part of this study is the After Reading evaluations of the textbooks. For this, first of all, the questions in the chapters were investigated. The in-chapter and the end-of-chapter questions were counted; their types were examined and reported. Answers to all the questions were searched and checked if they were correct and if they were on the same page as the question or not. TTKB Criteria also has guidelines for each type of question. All the questions in the chapters (both in-chapter and end-of-chapter questions) were inspected to see if they meet these specific criteria. The organization of the end-of-chapter questions was also assessed and reported.

The experiments and the activities suggested in the chapters were also included in the evaluation. The materials, and how to access these materials were investigated. In addition, ethical considerations, safety, and safety warnings of the experiments and activities were also assessed.

Another aspect under investigation was the figures of the chapters. All the figures were counted; their numbering, legends and location in the chapters were evaluated. The information on the figures was checked, any missing and wrong information was reported. Furthermore, the figures were compared with their originals to see if they were the same as their sources. The connections of the figures with other subjects, and if they eliminate students' misconceptions were also assessed.

The last stage of the textbook evaluation part of this study was the inspection of the textbooks' design. TTKB introduces several criteria for how textbooks should be designed. The researcher checked the textbooks according to the elements described in the criteria.

Evaluation of the Online Materials Provided by the Textbooks

The second part of the study involved a detailed evaluate on of the online materials provided by the textbooks. For the MoNE textbooks, the online materials were reached by the QR codes printed on the textbooks. For the IBDP textbooks, the websites were provided at the beginning of the textbooks. The evaluations were done through detailed investigations of the online materials provided. For the MoNE textbooks, links to all the activities and questions were tried to reach; the ones that worked were solved and evaluated. For the IBDP textbooks, the websites provided in the textbooks were visited, the available materials were investigated. The findings were reported.

Nature of Science

Different parts of the textbooks were used for the investigation of the NoS. For MoNE books, the reading passages given in the chapters were used to evaluate the NoS aspect of the genetics-related chapters of the textbooks since they are not

specified in the curriculum and reflect the textbook view on NoS. There were two reading passages in the Grade 10 textbook and two reading passages in the Grade 12 textbook. For the IBDP textbooks, the sections specified as "Nature of Science" in the textbooks were used. The Oxford University Press textbook has NoS boxes in almost all the sections in the chapters. Similarly, the Cambridge University Press textbook has a NoS subheading at the end of each section. Within the reading texts, NoS boxes and NoS subheadings, each paragraph was considered as one "unit" to be classified into one of the four NoS categories. After the classifications were done, the balanced representation of these four categories were investigated to see the depth of NoS in the textbooks. The findings and the interpretations of the data are given in Chapter 4 and Chapter 5, respectively.

CHAPTER 4: RESULTS

Introduction

The aim of this study is to compare how the topic of genetics is covered in four biology textbooks; Grade 10 and Grade 12 MoNE textbooks as well as Oxford University Press and Cambridge University Press IBDP textbooks were evaluated..

The research involved a careful comparison of all the chapters related to genetics. This comparison evaluated the followings: content, online materials provided with the textbooks and Nature of Science. The findings from this analysis are provided below. While reporting the findings, the researcher will occasionally speak in first person to convey her own experience with the textbooks.

Evaluation of the Content of the Textbooks

The framework for the evaluation is provided in the previous chapter. All the evaluations were done according to the criteria published by TTKB. These criteria were developed for the evaluation of MoNE textbooks; in this study, they were also used to evaluate the IBDP textbooks. The rationale for the use of the MoNE criteria to evaluate IDBP textbooks is because these books are used in Turkish classrooms and in schools accredited by the MoNE; therefore, they should also follow the guidelines followed by MoNE.

The following sections are organized according to the TTKB criteria, the details of which can be found in Appendix A. While explaining the results, the criteria will be explained briefly, followed by details of each textbook. Firstly, textbooks' links to curriculum are explained. Later, the mistakes in the textbooks are be introduced. These are followed by the use of terminology in the textbooks, differentiated learning strategies, questions and activities and figures present in the

textbooks. The section is finished with the evaluation of the connections to other subjects, definitions in the textbooks and gender equity.

Links to Curriculum

A part of the overall review of the textbooks involved assessing their links to the curricula. In TTKB criteria, it is stated that all objectives in the curriculum should be met in the textbooks. All four of the books covered all the objectives in their respective curricula. However, the percentages of IBDP textbooks dedicated to genetics chapters were higher than what is given in the curriculum. Within the IBDP curriculum, 15 hours of teaching is dedicated to Chapter 3, 9 hours is dedicated to Chapter 7 and 10 hours is dedicated to Chapter 10. These make 6.98%, 4.19% and 4.65% of all teaching hours, respectively.

MoNE Grade 10 Textbook

Within the MoNE curriculum, 41.70% of teaching is dedicated to teaching genetics in Grade 10 whereas only 24.9% of the textbook is dedicated to this chapter.

MoNE Grade 12 Textbook

Within this textbook, 38.9% of all teaching should be dedicated to teaching genetics, however, only 30.57% of the textbook is dedicated to the genetics chapter.

IBDP Oxford University Press Textbook

For the Oxford University Press Textbook, Chapter 3 takes up 11.72%, Chapter 7 takes up 6.05% and Chapter 10 takes up 5.27% of the textbook.

IBDP Cambridge University Press Textbook

For the Cambridge University Press Textbook, 11.35% of the textbook is dedicated to Chapter 3, 7.12% is dedicated to Chapter 7 and 7.65% is dedicated to Chapter 10.

Mistakes and Missing Information

In the TTKB criteria, it is clearly stated that the textbooks should not have any mistakes or missing information. All textbooks were evaluated to see if there were any mistakes and missing information in the chapters.

MoNE Grade 10 Textbook

In this book, there were no missing information or mistakes in the text. However, there were some mistakes in the reading texts. For example, the "News Corner" reading text about Aziz Sancar had grammatical mistakes. Firstly, there was an incomplete sentence on page 112. In addition, there were problems with the suffixes in the same reading text. The sentences can be accepted as "correct" in daily language but grammatically, they are not.

MoNE Grade 12 Textbook

There were no scientific mistakes in this textbook however, some of the concepts were simplified such as the process explaining how PCR and gel electrophoresis work (Page 63). Also, not all the enzymes in transcription and translation were mentioned. The curriculum states that the students should only know about Helicase, DNA Polymerase (not mentioning different types) and DNA ligase which were the only enzymes the textbook explains. In addition, there were mistakes in the reading texts on page 45, similar to MoNE Grade 10 Textbook. To start with, around the middle of the first paragraph, the term "çok aşırı (can be translated as too very much)" is not a

correct use. Moreover, in the next part of the same reading text about the heart attack gene is called the “TNF--gene”, which should be named as TNFα. Lastly, in the same paragraph, the gene that is responsible for coronary heart disease was explained as “the gene found on the q26 locus of gene number 15”; this should be corrected since the genes are found on Chromosome 15, not gene 15. Finally, on page 62, the textbook states that there are 25000-30000 genes in the human genome. However, Human Genome Project showed that this is not the case and the number of genes in the human genome was updated as 20000-25000 in 2004 (International Human Genome Sequencing Consortium, 2004).

IBDP Oxford University Press Textbook

In this book, codominance was explained incorrectly. It was stated that if there was codominance between alleles, the heterozygous individual would show a phenotype between the alleles; even an example of pink flowers was given (Page 172). However, this is incomplete dominance. In codominance, the phenotypes of both alleles should show at the same time in a mosaic manner. In addition, when the haploid cells were introduced on Page 154, it was not said which cell in the humans had haploid nuclei so students might get confused. Also, in the same section, it was stated that “haploid nuclei in humans contain 23 chromosomes for example”. This might lead to a misconception, leading students to believe there were other types of haploid cells in humans with different chromosome numbers.

IBDP Cambridge University Press Textbook

There were several mistakes in this book, all of which were in Chapter 3. First of all, the explanation of sickle cell anemia was wrong on page 95. The

coding strand and the non-coding strand were written in reverse. It was stated that the mutation happened in the non-coding strand where the mutation happens in the coding strand. This was corrected in the next paragraph. A similar mistake was made again on the same page when explaining the general idea of coding and non-coding strands. It was stated that the transcribed strand was called the "coding strand" however, the non-coding or the template strand was transcribed. In addition, the explanation for codominance might the confusing to the students (Page 115). Although the explanation was not wrong, it was not clear. Also, multiple alleles were explained in the same section. This order might lead to a misconception that all multiple alleles should have codominance. Lastly, on pages 126 and 128, there was a mistake about hemophilia and Factor XI deficiency. In the box on page 126, it was stated that Factor XI deficiency was different from hemophilia whereas, on page 128, it was stated that Factor XI was used to treat hemophilia. This might lead to confusions among the students. In reality, Factor XI deficiency is referred to as "Hemophilia C", which is a rarer type of hemophilia.

Terminology

It is very clearly stated in the TTKB criteria that the textbooks should use the correct terminology. In all of the textbooks, biological terminology was used correctly, with no errors, and in appropriate places. There were no mistakes in spelling and Turkish, English or Latin words.

MoNE Grade 10 Textbook

If English or Latin words were used (including the names of the scientists, cities and other places), the pronunciation was provided. This might help the students solidify the concepts and make sense of the topic better.

MoNE Grade 12 Textbook

Similar to MoNE Grade 10 textbook, the Turkish pronunciations of the terms used is provided in this textbook too.

Oxford University Press Textbook

Terminology was used accurately, however, on page 448, the fruit fly was only referred to as *Drosophila whereas* the scientific name is *Drosophila melanogaster.* Although in informal language, the fruit fly is referred to as only *Drosophila,* this distinction was not explained. This might cause the students to have some misconceptions since in the classification topic, they learn about the binomial naming system and this is different from what they learned.

Cambridge University Press Textbook

Terminology is used accurately in this textbook.

Differentiated Learning Strategies

As a part of the TTKB criteria, textbooks should have a range of differentiated learning strategies to cater to the needs of different students. Having different differentiated teaching strategies can be very beneficial during teaching. When these strategies are given by the textbook, this helps the students and the teachers at the same time; the students can benefit from the textbook even if they are studying by themselves. On the other hand, teachers can use the suggested strategies and implement them in their teaching in the classroom.

MoNE Grade 10 textbook

In this textbook, there were two "Araştırın/Araştırma [Reseach]" boxes which encouraged the students to learn on their own. In addition, there were different activities in the textbooks. These activities included creating a concept map, primrose experiment and reading texts. The details of the activities are given later in this chapter in the section titled *Activities and Experiments Enforcing Learning*

MoNE Grade 12 textbook

In this textbook, there were also five "Araştırın/Araştırma [Reseach]" boxes similar to Grade 10 textbook. Moreover, there were questions, designing a DNA to chromosome model, presentation, research and reading texts.

IBDP Oxford University Press Textbook

There were different activities in the chapters, helping students with different learning types. However, they were not comprehensive. Most of these activity boxes were reading texts, sometimes followed by questions.

IBDP Cambridge University Press Textbook

There were no differentiated learning strategies in the textbook.

Questions Asked in the Textbooks

TTKB has criteria for how different types of questions should be written. For this step of the study, all the questions were read and solved. All the questions were evaluated according to the TTKB criteria.

MoNE Grade 10 textbook

There were 18 in-chapter questions, all of which were short answer questions. Similarly, there were 15 solved questions, 14 of them being short answer questions and one being check all that apply type of question. Finally, there

22 end-of-chapter questions in this textbook. Of these 22 end-of-chapter questions, 11 were short answer questions, four were matching questions, four were reading comprehension questions and three were multiple choice questions. All the answers for the in-chapter and end-of-chapter questions were provided at the end of the book. Only the answers to the solved questions were on the same page as the questions. TTKB states that the answers and the questions should not be on the same page. These questions might be considered as exceptions for this criterion since they are specifically labeled “Solved questions”. All the questions complied with the criteria stated by TTKB.

MoNE Grade 12 textbook

There were 17 in-chapter questions (as a part of the activities) and 55 end-of-chapter questions in this textbook. The questions were grouped according to their types; there were 16 fill-in-gap questions, 28 multiple choice question, six data-based questions, four short answer questions, and one matching question. Only the answers to the end-of-chapter questions were provided at the end of the textbook. The in-chapter questions were labeled as “Activity” and did not have answers. All the questions complied with the TTKB criteria except for one matching question in-chapter. TTKB stated that there should be more definitions than terms in matching questions, however, in this question, the number of definitions and terms were equal.

IBDP Oxford University Press Textbook

In this textbook, there were 51 questions in total (48 in-chapter and 3 end-of-chapter) in Chapter 3. All the in-chapter questions were data-based questions and all the end-of-chapter questions were long answer interpretative

questions. In addition, there were 31 questions (28 in-chapter and 3 end-of-chapter) in Chapter 7. Similar to Chapter 3, all the in-chapter questions were data-based questions whereas there were two short answer questions and one interpretive question in the end-of-chapter questions. Lastly, there were 36 questions in total (32 in-chapter and 4 end-of-chapter questions) in Chapter 10. Unlike the other two chapters, there were 7 "Skills" questions in this chapter in addition to 25 data-based questions. End-of-chapter questions consisted of two short answer questions and two interpretive questions. All the answers were provided online and all the questions complied with the criteria stated by TTKB.

IBDP Cambridge University Press Textbook

There were 50 questions in total in Chapter 3; 39 in-chapter questions and 11 end-of-chapter questions. Of those 39 in-chapter questions, 31 were short answer "Test Yourself" questions and eight were worked examples. In the end-of-chapter questions, there were six multiple-choice questions, two short answer questions and three long answer questions titled "Exam Style Questions". In Chapter 7, there were 20 questions in total (11 in-chapter and 9 end-of-chapter). All the in-chapter questions were short answer, whereas six out of nine end-of-chapter questions were multiple choice and the rest being long answer questions. Finally, there were 36 questions in total in Chapter 10; 32 in-chapter and 4 end-of-chapter. There were 25 short answer questions in the in-chapter questions and 7 "Skills" questions. Of the end-of-chapter questions, two were short answer and two were interpretative questions. The answers to all questions were provided. The answers to the end-of-chapter questions were online whereas the answers to the Test Yourself questions

were in the back of the textbook. All questions complied with the TTKB criteria.

Activities and Experiments Enforcing Learning

Considering that both MoNE and IBDP curricula encourage students to be responsible for their own learning, having hands-on experiments and activities is a very important aspect of teaching. Thus, it is essential for textbooks to provide students and teachers with activities and experiments. To this end, all the activities and experiments in the textbooks were evaluated.

MoNE Grade 10 textbook

In this textbook, there were two activities. The first one was creating a concept map about inheritance. This activity was in line with the criteria suggested by TTKB; easy to incorporate into the lesson and no materials were needed. This activity could be implemented easily in every classroom all around the country. However, the second activity was an experiment about environmental effects on inheritance. Primroses, three aquariums and three sand heaters were needed. In addition, this was an experiment that lasted for four weeks. So, the materials were hard to find, there were a lot of materials needed for the experiment with a relatively long duration. Hence, this activity did not fit the criteria suggested by TTKB. Both the activities were safe for the students so there were no safety concerns (the second activity had safety precautions printed on the page).

MoNE Grade 12 textbook

There were seven activities in this textbook. However, two of them were not numbered; they were questions with the title “Activity: Question”. The first question was about the scientists Franklin, Watson and Crick. This activity

was not in line with the curriculum since the curriculum explicitly states that the students are not required to memorize the names of the scientists and the chronological order, but the question directly asked, “briefly summarize the research of these scientists”. The second question activity consisted of three parts. The first part was matching the enzymes with their functions. The second part was numbering the events of eukaryotic DNA replication and the third part was a short answer question about the DNA replication experiment using 15N. The first numbered activity, other than the two “Activity: Question”, was designing a model about showing how nucleotides, DNA and chromosomes were related. This activity did not require any special materials and could be done with what was available to the students. The second activity was preparing a presentation about protein synthesis as a group. In this activity, the students were divided into groups of five and they were expected to work together to prepare a presentation. The students were given a week for this activity. Similar to the first activity, there were no special materials needed. In the third activity, the students were expected to work as groups to do research on genetic engineering and biotechnology. They should be sharing their findings with their classmates. This was an activity that could be adapted to all classrooms, the duration could be adjusted. However, a computer with an internet connection or a library was needed for research. In the fourth activity, the students were expected to work in groups to research model organisms and present their findings to the rest of the class. Similar to the third activity, this could be adjusted to the needs of the teacher and the classroom. The fifth and the final activity was also a research and presentation activity about biosafety and bioethics. In all of these activities,

there were no safety warnings since there was no need. There were also no ethical concerns. However, one might argue that the activities are not differentiated since they were very similar to each other.

IBDP Oxford University Press Textbook

There are seven activities in Chapter 3. Six of them were discussion questions that encouraged students to think about the applications of the topics they were learning. The other activity was an experiment to visualize chromosomes from garlic. The activity was not designed as a manual for how to do this experiment, so the teacher should play a big role in how this experiment should be done in the classroom. Materials were not listed. There were no safety or ethical warnings for this experiment.

There were three activities in Chapter 7. Similar to most of the activities in Chapter 3, all three activities were discussion questions, helping the students to think about real-life applications of the topics. There were no activities in chapter 10.

IBDP Cambridge University Press Textbook:

There were no activities in this textbook.

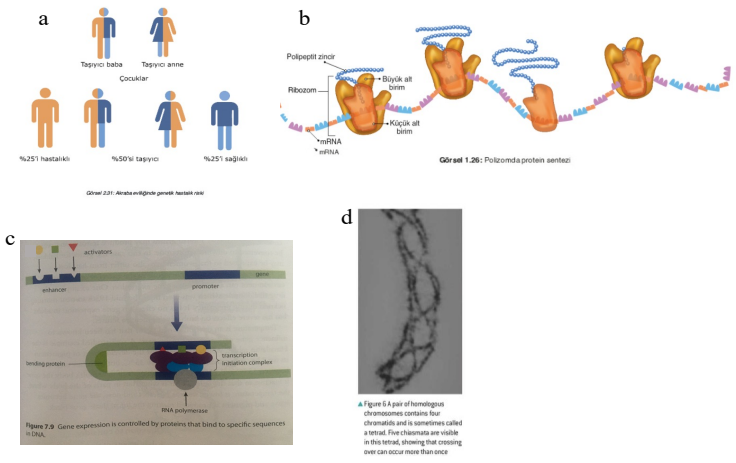
Figures Enhancing Learning

In this step of the study, all the figures in the chapters were evaluated. Some figures in all four of the textbooks were especially useful. For example, Example 1 is from MoNE Grade 10 textbook, which illustrates how consanguineous marriages increase the changes of rare genetic diseases (Figure 1a). In addition, Example 2 is in MoNE Grade 12 textbook, which shows polysomes. This might be a concept that might be confusing for the students since they need to visualize mRNA, several ribosomes and translation at the same time. However, they have just learned about

the topic thus it might be hard for them. This figure shows protein synthesis in polysomes, making the concept more concrete for the students (Figure 1b). Similarly, Example 3 form Cambridge University Press textbook illustrates how gene expression is mediated by proteins that bind to sequences other than the actual gene. This might be a difficult concept for the students since they are still learning about what genes are, how they are expressed and what are the factors that affect their expression are. Seeing an illustration of how enhancers control gene expression can be very beneficial for their understanding of the concept (Figure 1c). Finally, Example 4 is from Section 3.3 in Oxford University Press textbook. It is an electro-microgram image of a pair of homologous chromosomes. Students are learning about genes and DNA, but it might be difficult for them to realize what can be seen with a microscope and what scientists use when they are making their interpretations. Hence, students need to see an actual microgram (Figure 1d).

Figure 1

Especially Useful Figures in the Textbooks



Note. All figures were taken from the textbooks. A. Example 1 from MoNE Grade 10 textbook. B. Example 2 from MoNE Grade 12 textbook. C. Example 3 from Oxford University Press textbook. D. Example 4 form Cambridge University Press textbook.

Overall, all four of the books generally complied with the criteria stated by TTKB with some exceptions. In all of the textbooks, the figures were numbered, with legends different from the text. In addition, the figures were not the same as the originals. Individual explanations for textbooks are given below.

MoNE Grade 10 textbook

There were 24 figures in total in this textbook. Although the figures were numbered, the order of the figures was wrong. The figures were numbered …2.21, 2.24, 2.22, 2.23, 2.25… There were no other problems with the rest of the figures. They were all purposeful, with no missing information.

MoNE Grade 12 textbook

There were 53 figures in this textbook. Figure 1.47 might be a cause for misconception since it was a stock image about gene therapy showing a scientist holding a piece of DNA with tweezers. This is not possible and it might lead students to misunderstand the concept of gene therapy, how it is actually done and how small DNA actually is. All the figures were on the same page as the text, except Figure 1.41. However, this was understandable since the figure was a larger one showing cloning and experiments with Dolly. It took half of the page and it would have been hard to fit it on the same page as the explanation without disrupting the order of explanation. Furthermore, some of the figures were not very meaningful in this textbook. There were many stock images that were generic and not special to the textbook. Especially Figure 1.52 about biosafety did not make any sense as it was not related to the subject. In addition, because most of the figures were of stock images, they were the same as the originals, with references.

IBDP Oxford University Press Textbook

There were 76 figures in Chapter 3, 49 figures in Chapter 7 and 31 figures in Chapter 10 in this textbook. All of these figures were numbered. Most of the figures had very short legends that were different than the text, however, some of them did not have one at all. For example, the figures in the questions did not have legends. All the figures were purposeful, and they worked to eliminate misconceptions. Some of the figures were not on the same page as the text.

There was a mistake in the Figure 1 in Chapter 3. A map of Chromosome 7 was shown, however, both arms were labeled "q". The longer one should be the "p" arm.

IBDP Cambridge University Press Textbook

There were 25 figures in Chapter 3, 23 figures in Chapter 7 and 19 figures in Chapter 10. All of the figures were numbered and had legends. The legends were not the same as the text. However, some of the figures might lead to misconceptions. For example, in Figure 3.19, the cells were almost half the size of the pancreas and there was no reference to scaling. So this might lead the students to believe that these were especially big cells. All the figures had a purpose. On the other hand, some of the figures were not on the same page as the text.

Connections to Other Subjects

In the TTKB criteria, it is suggested that the textbooks should have connections to other subjects. This is very important since the students should not learn the subjects as isolated topics but they should be able to make connections with what they have learned previously. This is especially important for genetics since it

is related to almost every topic of biology. In addition, these connections to other subjects help students to make sense of the information.

Both the MoNE and the IBDP curricula state that the students need to realize biology is not an isolated subject, the topics are related to each other, and to other subjects as well as technological developments (MoNE, 2018b, p. 11l; IBO, 2014, p.21). All four of the textbooks efficiently link biology and genetics to other subjects. Details for each textbook is given below.

MoNE Grade 10 textbook

In this textbook, there were links to other topics. For example, when the blood types were explained, terms such as antibodies and antigens were mentioned. The students will learn about them in Grade 11. In addition, some genetics terms, like locus, were explained in a previous chapter about cell divisions.

MoNE Grade 12 textbook

In this textbook, ethical, philosophical and religious aspects of biology were referred to. The students were encouraged to think about these aspects especially in biotechnology and bioengineering topics.

IBDP Oxford University Press Textbook

In this textbook, other sub-sections were mentioned throughout the chapters. In addition, Theory of Knowledge (ToK) and Nature of Science (NoS) were referred to in boxes.

IBDP Cambridge University Press Textbook

In this textbook, other sections were mentioned constantly. For example, in the introduction to Chapter 7, subsections 2.6 and 2.7 were referenced. Furthermore, the Theory of Knowledge (TOK) and Nature of Science (NoS)

were mentioned at the end of each subsection. Moreover, on Page 128, the term “eutrophication” was made bold for emphasis but it was not explained. This is a part of the Environmental Systems and Societies subject, a part of both Group 3 and Group 4.

Definitions

In the TTKB criteria, it is stated that the definitions should be clear in the textbooks So as to avoid misconceptions.

MoNE Grade 10 textbook

The definitions were clear and easy to understand in this textbook.

MoNE Grade 12 textbook

The definitions were clear and easy to understand in this textbook.

IBDP Oxford University Press Textbook

The definitions were clear and easy to understand in this textbook.

IBDP Cambridge University Press Textbook

Most of the definitions were clear in this textbook. However, as mentioned above, codominance and multiple alleles section might cause misconceptions and confusions in the students. Furthermore, Deoxyribonucleotide Triphosphate (dNTPs) were not explained clearly in Chapter 7. This might lead to misconceptions about dNTPs and what they are.

Gender Equity in Examples

According to the TTKB, the examples in the textbooks should not be discriminating against any group. All the textbooks were examined to look for examples of gender equity and to ensure no populations were discriminated against in the text or graphics. By including the images of females, the textbooks show that

females can be researchers and scientists. Overall, it appears efforts were taken to provide examples of males and females working in science.

MoNE Grade 10 textbook

In this textbook, Aziz Sancar was given in the "News Corner" as an example of a scientist, but in the pre-assessment part, a female scientist was shown. It is also notable that the image of the female scientist was wearing a headscarf; this could be meant to convey that religious beliefs are not an obstacle to being involved in science. There were no other images and examples of scientists given in this chapter.

MoNE Grade 12 textbook

In this textbook, eight males and eight females were given as examples. Seven of these eight male examples were of actual scientists (like James Crick and Aziz Sancar) whereas only two of the females were examples of real scientists (like Rosalind Franklin and Martha Chase).

IBDP Oxford University Press Textbook

In this textbook, there were not many gender-specific examples. Most of the examples were about diseases or other conditions. When there was an example, it was very inclusive. For instance, there was an example showing different ways a family can be formed. There was an image of a scientist, but the gender could not be identified. The environmental effects were shown by giving a pair of male identical twins, showing how different diet and exercise could change the body composition. This was the only human example in Chapter 10. Finally, more male scientists were mentioned but this might be explained, similarly with Grade 12 textbook, as there were more male scientists working at that time.

IBDP Cambridge University Press Textbook

In this textbook, not many males or females were mentioned. Most of the examples were about diseases. In addition, when there was a scientist as an example, the gender was not identified.

As a part of this study, other features of the textbooks that is not directly related to genetics were also evaluated. These include the cover of the textbooks, overall design of the textbooks, general features of the textbooks, references in the textbooks and advertisements in the textbooks. The findings are given in Appendix B.

Evaluation of the Online Materials

In today's society, online materials are just as important as the written textbooks. To this end, the online materials provided with the textbooks were also evaluated. In both of the MoNE Textbooks, there were QR Codes in the textbooks that directed the students to a webpage. On these pages, the students can access questions, activities and the interactive version of the textbooks whereas, for both of the IBDP textbooks, the students should access another webpage.

MoNE Grade 10 textbook

Although the activities and the videos could be reached by a QR code; the videos did not work. When a student tried to reach the video, there was an error saying "video not found". Figure 2 shows a screenshot for when the researcher tried to reach one of the videos, but it was not available. Similarly, the activities for this textbook also did not work. While the questions could be reached, there were some mistakes in the questions. There were 41 questions in total for Grade 10. Question 4 asked which of the following cannot be explained by inheritance only, with "Height" being an incorrect

option. However, Question 10 asked which of the options were due to interactions between genetics and environment and the answer was again height. There was a contradiction in the answers. Height was said to be both environmental and genetic in Question 38 again. In addition, there were some questions about Anti-D Antibody. Nevertheless, Rh-Factor was not referred to as Anti-D in the textbook, which might lead the students to confusion.

Figure 2

Screenshot Showing the Video is not Available for MoNE Grade 10 Textbook

MoNE Grade 12 textbook

Similar to Grade 10 textbook, the videos for this textbook also did not work. On the other hand, activities sometimes worked, sometimes did not. This suggested that the links provided by MoNE were not reliable. However, this might be due to the high traffic of the pages because of online learning. The activities for Grade 12 online materials were the same as the activates in the textbook, there was no indication of this on the textbook, so students might try to reach these thinking there will be additional activities. There were 61 questions in total for this textbook. There were also some mistakes in the questions. For example, there was a typo in Question 1 for Process of discovery of Nucleic Acids, the name of the bacteria strain was written

incorrectly (it was written as *Streptococcuc* when it should have been *Streptococcus*). In addition, in the same question, it was stated that the "bacteria without capsule causes pneumonia. The without capsule form of the same bacteria does not cause disease". This statement is incorrect as bacteria with capsule cause disease. Furthermore, in Question 1 for Organization of the Genetic Material in the Cell, it was stated that the executive molecule for all living organisms was DNA. However, there are RNA viruses which have RNA as the executive molecule. The statement in the question is not scientifically correct even though, RNA viruses were not mentioned in the textbook. Moreover, in Question 3 for Protein Synthesis, it was stated that the mRNA codon numbers must be the same for two proteins with the same number of amino acids. This was not certain since the non-translated regions of the mRNA might be of different lengths. Similarly, the non-translated regions of the mRNA were ignored in Question 10. In Question 8, a protein with different numbers of different amino acids was given, the different types of anticodons and the number of codons were asked, taking the stop codons into consideration. The question did not consider the fact that all proteins must have the amino acid Methionine since it is the start codon. If the students were instructed to think about the stop codons, they should also think about the start codon and the amino acid it codes for. In addition, there was a discrepancy between Questions 2 and 5 in Applications of Genetic Engineering and Biotechnology. In Question 2, it was implied that stem cells cannot turn into any cell type but in Question 5 the statement was considered as correct. Finally, the last question was asked twice.

IBDP Oxford University Press Textbook

The online materials for this textbook were provided with another webpage named Kerboodle. This included worksheets, practicals, answers to questions and planning ideas for teachers (the students did not have access to this part). However, in order to reach these resources, schools need to be registered. Hence, only paying for the textbook is not enough to get the full range of teaching materials provided. On the other hand, all the answers to the questions can also be accessed freely from the Oxford webpage.

IBDP Cambridge University Press Textbook

Free online materials were provided with the textbook. The students should visit the webpage provided in the textbook and register. Once they are registered, online materials can be accessed. However, the online materials were labeled as "Teacher Resources" so the students might not be interested in these resources unless specifically instructed by their teacher. The resources included Option Chapters, answers to questions, practical and teaching ideas. All the materials should be accessed individually. I last accessed this page on 23.03.2020; when I tried to access the online materials again the interface had been changed, and a new registration was needed. In the new version of the online materials, the students were expected to add the curriculum they wished to access (for example International Baccalaureate Biology) and add the resources onto their account. This was free. Once the resources were added, there was an option to download all the materials at once, there was no way of choosing which materials to download. This leads to a .zip file download to the computer with different resources including the Option chapters, answers to questions, self-assessment questions, internal assessment student guide and teacher guide, external assessment guide,

practicals, teaching ideas and images that could be used as support during lessons. Although this was an extensive folder, there were many different files and navigating all the resources, trying to find the most appropriate ones was difficult for both the teachers and the students. In addition, the fact that the online resources had changed before the end of the school year might have been confusing for both the teachers and the students.

Nature of Science

Nature of Science (NoS) is a very important aspect of teaching science. Thus, for the final part of the study, NoS aspects of each textbook were analyzed. Two reading passages in the both MoNE textbooks were used for the evaluation while the NoS Boxes at the end of each section of Oxford University Press textbook and NoS subheadings in Cambridge University Press textbook were for the investigation. All these readings are referred to as "Text" while reporting the findings. Each paragraph or figure is the units that are classified into one of the four categories of NoS. The unit is classified into Category 1 if the unit gives direct information to the students; the unit is classified into Category 2 if students are actively performing a task; the unit is classified into Category 3 if the unit explains the scientific process and finally, the unit is classified into Category 4 if it explains how science is interconnected with society and technology. The findings are shown in Table 3.

In the table, each textbook has specified "Texts," labeled from 1 up to 5. These "Texts" are the reading texts from the MoNE textbooks, the NoS textboxes in Oxford University Press textbook and NoS subheadings in the Cambridge University textbook. Within these "Texts," based on the framework, every paragraph and figure in the texts are considered as "units" and the units are classified into one of the four categories of NoS provided by the framework.

Table 3

Nature of Science representation in textbooks

		Frequency of Units Classified Into Each Category			
Textbook	Text	Category 1 Direct Knowledge	Category 2 Student Engagement	Category 3 Scientific Work	Category 4 Science Interactions
MoNE Grade 10					
	Text 1	5	0	3	0
	Text 2	2	0	0	1
	Total	7	0	3	1
MoNe Grade 12					
	Text 1	5	0	2	1
	Text 2	2	0	1	1
	Total	7	0	3	2
Oxfrod University Press					
Chapter 3	Text 1	0	0	2	1
	Text 2	0	0	3	2
	Text 3	1	0	3	1
	Text 4	5	0	1	0
	Text 5	0	1	2	1
Chapter 7	Text 1	1	0	4	1
	Text 2	4	0	0	0
	Text 3	2	0	4	2
Cahapter 10	Text 1	0	0	2	0
	Text 2	0	0	2	0
	Text 3	1	0	0	0
	Total	14	1	23	8
Cambridge University Press					
CH3	Text 1	2	0	3	0
	Text 2	2	0	3	0
	Text 3	1	0	1	0
	Text 4	0	0	1	0
	Text 5	4	0	3	2
CH7	Text 1	1	0	3	0
	Text 2	1	0	0	1
	Text 3	7	0	1	0
	Text 4	0	0	1	2
CH10	Text 1	1	0	2	0
	Text 2	1	0	3	0
	Text 3	2	0	0	0
	Total	22	0	21	5

None of the textbooks had completely balanced NoS representation. There were 114 classifications in total. There were 50 units classified into Category 1 and 47 units classified into Category 3. This suggests that all four of the textbooks had given importance to relaying information and showing the scientific process to students. In the meantime, 16 units were classified into Category 4. Nevertheless, there was only one unit that was classified into Category 2. This shows that almost

no importance was given to hands-on experience of students in the NoS sections in all four of the textbooks.

MoNE Grade 10 Textbook

The two reading texts evaluated in this textbook mostly involved knowledge production. The first text had four units and the second text had two units. All of these units gave direct information to the students. In addition, the last three units of text one showed students the way of thinking of Aziz Sancar and how science works, hence those three units were also classified into Category 3. Similarly, the second unit in Text 2 gave examples about how technology and science are interconnected with each other, thus being classified into Category 4 together with Category 1. All things considered, the introduction of NoS in this textbook was not balanced, it was very much skewed in favor of the production of knowledge. In total, seven units were classified into Category 1, three units were classified into Category 3 and two units were classified into Category 4. No units were classified into Category 2.

MoNE Grade 12 Textbook

Similar to MoNE Grade 10 textbook, there were two texts evaluated for NoS in this textbook. The first text had seven units, five of which are classified into Category 1. Two are classified into Category 3 and one is classified into Category 4. Text 2 was more diverse even though two out of three units were classified into Category 1. However, one of these units was also classified into Category 3 since it showed students how science progressed. In addition, one of the units was also classified into Category 4, as it explained how science and scientific breakthroughs can affect people's lives. All in all, NoS

representation in this textbook was not very balanced, with seven units classified into Category 1, three units classified into Category 3 and two units classified into Category 4. No units were classified into Category 2. This dispersion was exactly the same as the MoNE Grade 10 Textbook.

Oxford University Press Textbook

In this textbook, the "Nature of Science" boxes for each section were evaluated. In total, there were five texts in Chapter 3, three texts in Chapter 7 and three texts in Chapter 10. Text 1 in Chapter 3 consisted of three units, two classifying in category 3 and one classifying in Category 4. Similarly, Text 2 also had three units; two of which classified into category 3 and one classified into category 4. However, one of the units was classified into both Category 3 and Category 4 since in this unit both how science progresses and how technology is involved in science were introduced at the same time. Text 3 in Chapter 3 was mostly about the scientific method, science progression and technology, with three units classified into Category 3, one unit classified in Categories 1 and 4. Text 4 was a very descriptive text, with five out of six units being classified into Category 1. On the other hand, Text 5 in Chapter 3 might be considered as one of the most balanced texts since it had units classified into three different categories. Two units were classified into Category 3, one unit is classified into Category 2 and one unit is classified into Category 4. One should also note that this text was the only one where a unit was classified into Category 2 in all four textbooks.

Texts in Chapter 7 were generally similar to each other. In the Text 1, there were five units. Four of these five units were classified into Category 3, one is also classified into Category 4 and the final one is classified into Category 1.

Nevertheless, Text 2 was one dimensional and all four of the units were classified into Category 1. The final text in Chapter 7 was the longest with nine units. Out of these nine units, two were classified into Category 1, four were classified into Category 3 and two classified into Category 4. This was one of the most balanced texts in all four of the textbooks.

There were three texts in Chapter 10 in Oxford University Press Textbook, all of which were quite unbalanced. Text 1and Text both had two units classified into Category 3, whereas all four units in Text 3 were classified in Category 1. All in all, this textbook was the most balanced in respect to NoS introduction with a total of 14 units being classified into category 1, one unit was classified into Category 2, 23 units into Category 3 and eight units into Category 4.

IBDP Cambridge University Press Textbook

In this textbook, the "Nature of Science" subtitles at the end of each section were evaluated. There were five texts in Chapter 3. In Text 1 and Text 2, there were five units; three of them were classified into Category 3 and the two of them were into Category 1. One of the units in Text 2 was a figure. Text 3 consisted of two units, one was classified into Category 3 and the other into Category 1. Similar to Text 2, the unit classified into Category 1 was a figure. Text 4 was made up of only one unit classified into Category 3. The final text in Chapter 3 was the most balanced one. There were four units classified into Category 1, three units classified into Category 3, and two units classified into Category 4.

In Chapter 7, there were four texts even though there are three sections in the chapter. There were two NoS subtitles in the first section. All four of the texts

were evaluated. Text 1 consisted of four units, three of them being classified into Category 3 and one into Category 1. The unit classified into Category 1 was a figure. Text 2 had two units, one being classified into Category 1 and the other into Category 4. In Text 3, there were seven units, all of which were classified into Category 1. In this text, Unit 3 was also classified into Category 3 since it showed students how science progressed. Text 4 consisted of two units. Both of them showed the students that scientists interact and collaborate with each other, and technology is an undisputable part of science. Hence, both of the units were classified into Category 4. In addition, Unit 1 also showed how science progresses so it was also classified into Category 3.

Similar to Oxford University Press Textbook, there were three texts in Chapter 10 in Cambridge University Press Textbook. Text 1 consisted of three units, two of them were classified into Category 3; one of the units gave direct information, so it was classified into Category 1. Text 2 consisted of four units. Three of them were classified into Category 3 whereas one of them was classified into Category 1. One of the units classified into Category 3 was a figure in this text. This figure was the only figure that was not classified into Category 1. This figure showed inheritance of sex-linked characteristics. There were illustrations of chromosomes and showed how the experiment was conducted. Thus, this unit was classified into Category 3. Finally, Text 3 had two units, both of them being classified into Category 1. All in all, Cambridge University Press Textbook mostly consisted of Category 1 and Category 3 units, having 22 and 21 units in each category

respectively, there were also five units classified into Category 4. There were not any units classified into Category 2.

CHAPTER 5: DISCUSSION

Introduction

The purpose of this study was to evaluate and compare genetics-related chapters in biology textbooks used by high school students in Turkey. Four textbooks were reviewed, two are used as part of the national education curriculum (MoNE) and two are used by the international education program, International Baccalaureate Diploma Programme (IBDP). In addition to having suitable textbooks for student learning of genetics, it is important to consider the needs of the teachers. Therefore, the outcomes of this study may help teachers decide on the textbook they would follow in their classrooms.

The study aimed to answer the following research questions:

1. How do the genetics-related chapters in two MoNE and two IBDP textbooks align with the TTKB criteria?
2. How do the supplemental online materials align with the TTKB criteria?
3. To what extent is the Nature of Science addressed in these genetics-related chapters?

This chapter provides a discussion of analyzed data from the textbook evaluations. In addition, implications for practice and research are presented. While discussing the findings, the researcher will occasionally speak in the first person to convey her experience and opinions about the textbooks.

Overview of the Study

To fulfill the aim of the study, all four of the textbooks were read thoroughly. They were evaluated according to the criteria suggested by a board called Talim

Terbiye Kurulu Başkanlığı [Turkish Board of Education] (TTKB). TTKB is a board in the Turkish Ministry of Natural Education (MoNE) which is responsible for choosing which textbook will be used in the classrooms. Considering the need, they publish a set of criteria, and all the proposed textbooks are evaluated according to that set of criteria. Consequently, one textbook for each subject is selected. For this study, both MoNE and IBDP textbooks were evaluated according to these criteria. Even though the TTKB criteria are specifically constructed to evaluate MoNE textbooks, the same criteria were also used to assess IBDP textbooks since these textbooks are also used in Turkish classrooms and they should conform to standards proposed by TTKB.

This study consisted of three parts: evaluation of the content of the textbooks, evaluation of the online materials provided by the textbooks and evaluation of how NoS is introduced in the textbooks. Each of these parts is described further below.

For the Evaluation part of the study, a framework summarizing the TTKB criteria was developed and applied. The evaluation of the textbooks' contents was done in three stages. First, general features of the textbooks, including the cover, book features and links to curriculum, were evaluated. Later, the text, the examples, terminology and resources were evaluated by reading the textbooks thoroughly. Then, all the questions in the textbooks were solved, all the activities, experiments, and figures as well as the designs of the textbooks were evaluated.

For the second part, online materials provided by the textbooks were also examined. All the online materials provided with the books were evaluated, the questions were solved, the answers were checked. In addition, the ease of use and access were also investigated. All the findings were reported in Chapter 4.

Finally, NoS parts of the textbooks were also evaluated. For NoS, a framework created by Chiappetta in 1999 and modified by Lee in 2004 was used during the evaluation (see Chapter 3). Different parts of the textbooks were used for this evaluation. For the MoNE textbooks, the reading texts in the chapters were used. Contrarily, the Nature of Science boxes were used for the Oxford University Press textbook and Nature of Science subtitles were used for the Cambridge University Press textbook. Qualitative content analysis was utilized in this study.

A thorough evaluation of the textbooks showed that none of the textbooks meet the criteria fully. While doing the evaluations, it was clear to me that the MoNE textbooks were much more student-friendly than the IBDP textbooks. Due to the fact that the language in the MoNE textbooks was informal, they gave the impression that they were talking to the readers. The IBDP textbooks, however, assumed the readers were already familiar with the content. In addition, since the IBDP textbooks are used for two years and MoNE textbooks are used for only one year, the IBDP textbooks are thicker and heavier. This might lead to some difficulties for students when they need to carry them to and from school.

On the other hand, IBDP textbooks provided more comprehensive online materials when compared to MoNE textbooks, which became especially important during the emergency online teaching due to the Covid-19 pandemic. The students can have more resources for their studies when they are not physically together with their teacher and thus have more access. Nevertheless, the online materials of the Oxford University Press textbook needed an additional paid registration, which was not the case in any other textbooks.

The introduction of NoS was similar in all four of the textbooks, even though IBDP textbooks had more texts when compared to MoNE textbooks. None of the textbooks had a balanced NoS introduction.

All in all, the findings show that none of the textbooks can be considered "perfect". However, if we were to create an "ideal textbook", it would have the language style of MoNE textbooks and the online materials of the Cambridge University Press textbook.

Discussion of Major Findings

The findings of this study are discussed in this section. The findings are presented in three parts: evaluation of the contents of the textbooks, evaluation of the online materials and the Nature of Science (NoS). All of which are also the research questions of the study. The corresponding research question will be given at the beginning of each sub-heading. Later, the findings regarding that research question will be discussed.

Evaluation of the Content of the Textbooks

Research question 1. How do the genetics-related chapters in two MoNE and two IBDP textbooks align with TTKB criteria?

The investigation involved checking the links of the textbooks to their respective curricula, any mistakes in the textbooks, terminology used in textbooks, differentiated learning strategies provided in the textbooks, figures and questions in the textbooks as well as gender equity in textbooks. Discussion of the findings are given below.

Links to Curriculum

All four of the textbooks covered all the objectives in their respective curricula. However, in MoNE Textbooks, the order was different from the one given

in the curriculum. This was in line with the criteria in which it is stated that the topics should go from simple to advanced. By changing the order of the objectives, the textbooks could comply with the criteria. Although the order was not changed in the IBDP textbooks, the Understandings already go from simple to advanced. On the other hand, for all the textbooks, there is a difference between how much time to be spent on genetics chapters suggested by the curricula and how much of the actual textbooks is dedicated to genetics chapters. Both MoNE textbooks dedicate less time than suggested in the curricula. Conversely, for both IBDP textbooks, genetics-related chapters take up more than what is suggested by the curricula. This might be explained by the difference in textbook usage of the two curricula.

Mistakes in the Textbooks

Another very important aspect of the TTKB criteria is the imperative fact that textbook must not have any mistakes or missing information. None of the MoNE textbooks has any scientific mistakes in them. However, there are problems in the reading texts in both MoNE textbooks. This suggests that maybe less importance is given to the reading texts than the actual explanations in the textbooks. On the other hand, there are mistakes in both IBDP textbooks. To start with, codominance is explained incorrectly in both books, causing a confusion between codominance and incomplete dominance. In the Oxford University Press textbook, the example is given as a pink flower (which is one of the most common examples for incomplete dominance). This might be due to the wording in the IBDP Biology guide. In section 3.4: Inheritance, one of the Understandings is stated as “Dominant alleles mask the effects of recessive alleles but co-dominant alleles have joint effects” (IBO, 2014, p.55). The distinction between codominance and incomplete dominance is not clear in this statement. “Joint effects” can be interpreted as showing a mosaic-like

phenotype with the effects of the two dominant alleles showing at the same time, which is codominance. On the other hand, “joint effects” can also be interpreted as showing a mixture of the two dominant alleles that is different from both, which is incomplete dominance (Miko, 2008). In the Cambridge University Press Textbook, the explanation is better, yet might still lead to misconceptions. In this textbook, codominance and multiple alleles are explained in the same section, with ABO blood groups as an example. Although this example is correct, it might lead to misconceptions in students implying that every time there is codominance, there should be multiple alleles and similarly, when there are multiple alleles, they should be codominant. This is not the case, yet it is not stated explicitly in the textbooks, which might lead to confusion among the students.

Furthermore, there are other mistakes. For example, in the Oxford University Press textbook, the introduction of haploid nuclei might be confusing to the students because of the wording. The students might assume that there are different types of haploid cells in the human body and the gametes with 23 chromosomes are the only example. Nevertheless, these are the only haploid cells in the human body, with no other examples. In the Cambridge University Press Textbook, there is a mistake while explaining sickle cell anemia. Coding and non-coding strands are used in reverse, stating that the mutation happens in the non-coding strand. Nevertheless, the mutation happens in the coding strand for sickle cell anemia. Although this mistake is corrected in the next paragraph, a similar mistake is also done on the same page in the information box, explaining the difference between coding and non-coding strands, stating that the coding strand is transcribed into mRNA. However, the non-coding strand (or the template strand) is transcribed into mRNA. Coding strand gets its name as is since it has the same code as the mRNA (Clancy, 2008). As this

mistake is in Chapter 3, so the students have not learned about transcription yet (which is given in Chapter 7).

Scientific mistakes, such as coding and non-coding strands, might be one of the most impactful mistakes that the students can encounter in their textbooks. Take, for example, coding and non-coding strands. The students are taught the wrong information even before they had the opportunity to learn the topic. Later in the course, they should be able to realize what they learned previously is not correct and thus they should relearn these concepts. However, students are generally resistant to changing the misconceptions they formed previously which makes correcting the mistakes in the textbook even harder (Tekkaya, 2002). In addition, the purpose of teaching is to help students love biology and make sense of the living world around them. Having discrepancies and mistakes in the textbooks might lead the students to resent biology and result in students opting out of a career in sciences.

While textbooks should be free of any mistakes, it is important to note that having small mistakes in the textbooks should not discourage teachers and students from using that textbook in their classrooms or for their learning. With the help of studies like this and input from teachers and students, editors can correct the mistake in their textbooks and improve the future editions of their textbooks.

Terminology Used in Textbooks

Textbooks should not just be a compilation of scientific knowledge they should also strive to enhance student learning. It has been long known that using correct terminology is vital in scientific community and communication (Wandersee, 1988). Thus, textbooks must use terminology appropriately. Correct terminology is used in every textbook which is very important since using correct terminology helps students understand the concepts better besides teaching them scientific consensus.

Furthermore, almost all of the definitions are clear in all the textbooks, except for the definition of dNTP in the Cambridge University Press Textbook. Having clear definitions is extremely important for a textbook. The definitions help the students understand the concepts and makes sure that there are no misconceptions. Correct terminology and clear definitions in all of the textbooks suggest that understanding of students was considered when the textbooks were being written.

Differentiated Learning Strategies

Another very important feature of textbooks is the differentiated learning strategies. Needs of all the students are different from each other. When teachers differentiate their teaching, it becomes a way of catering to the needs of all students. Individual differences in interests and talents of students will be considered in the classroom (Morgan, 2014). TTKB clearly states that textbooks should consider students with different learning needs. Differentiation is clear in both MoNE textbooks, aiming to enforce different types of learning with different activities and research opportunities. However, a comprehensive differentiation cannot be seen in IBDP textbooks. There are several activities in the Oxford University Press textbook, however, they are very similar to each other; mostly a reading text followed by some questions. Cambridge University Press Textbook does not have any differentiated learning strategies at all. This suggests that the teachers should incorporate strategies and activities that are not in the textbook into their teaching.

Use of Questions in the Textbooks

Questions can be used to identify misconceptions and misunderstandings of students. They can be an invaluable teaching strategy (Allen & Tanner, 2002). Similarly, students can test themselves through questions provided in the textbooks. All four of the textbooks have many questions throughout the chapters, both in-chapter and end-

of-chapter. This shows a clear consideration of student understanding. In all the textbooks, a range of question types was provided. This suggests that the textbooks took differing needs of students into consideration. Not all types of students will be beneficial to every student, thus providing students with varying questions can help them assess their learning better.

Activities and Experiments Enforcing Learning

Activities and experiments can help students solidify the concepts they are learning. Hence, having different types of activities and experiment during teaching can be invaluable. In three of the textbooks, except the Cambridge University Press textbook, there were activities and experiments. This shows that the textbooks are giving importance to students being responsible for their own learning. This is especially important since both MoNE and IBDP curricula emphasizes individual learning of their students.

Use of Figures in the Textbooks

Although supplementary to a textbook content, figures and questions in the textbooks are of utmost importance. Özay and Hasenekoğlu (2007) claims that interesting figures in the textbooks enhance student learning. Almost all the figures in all four textbooks are meaningful, working to enhance student learning (Examples of some the especially important figures are given in Figure 1 in Chapter 4). Figures can play an invaluable role in eliminating misconceptions. Biology, especially genetics, has many distinct concepts. Figures will help students make sense of the information they are learning. As it can be seen in Figure 1 (in Chapter 4), one of the most influential figures showed the consequences of consanguineous marriages. This is important since this is a very potent cultural issue that the students need to be aware of. The textbook emphasizing the repercussions makes the students realize the

potential consequences of consanguineous marriages at a young age. This is a great example of how teachers and school should thrive to enhance student learning in every aspect. Even though consanguineous marriages are a part of the curriculum, the textbook choose to give a striking example of the possible repercussions. This shows that the textbook is aware of an alarming issue in the society will be used.

Gender Equity in the Textbooks

Non-discriminatory actions are very important in today's society. Gender equity means that both males and females get equal opportunities in every aspect of life. Unfortunately, there has been inequality in the Turkish society for a very long time, labeling the males as the "bread-winners" and females as the "home-makers", "wives" and "mothers". This has been translated into education when young girls are kept home, uneducated (Sahin, 2014). To overcome this issue, there were several campaigns initiated by non-profit organizations, media organizations and governmental organizations. Two most impactful ones were Baba Beni Okula Gönder [Father Send Me to School], started by Aydın Doğan Media Group and Haydi Kızlar Okula [Girls, Let's Go to School], a joint campaign of UNICEF and MoNE (Özaydınlık, 2014). The efforts are still underway, to make sure that males and females get equal opportunities in education. TTKB also states that the textbooks should not have any statements, examples or figures that can be considered as discrimination against any group. All four of the textbooks comply with this criterion and take measures to eliminate discrimination, especially have equal gender representation. Males and females are shown in equal situations. In addition, in MoNE Grade 10 Textbook, a female scientist is shown wearing a headscarf. This is especially important since some students might think that religion and science cannot exist at the same time. Having a religious scientist clearly shows that personal beliefs

are never an obstacle for science, and everyone can become a scientist if they wish. The only exception for equal representation of males and females is when the work of real scientists is explained. Unsurprisingly, there are many more male scientists mentioned when explaining the progression of genetics. This is understandable since during the 17th, 18th and 19th centuries (when most of the groundbreaking advances were made in the field of genetics), there were many more male scientists working when compared to female scientists. Notably, all four of the textbooks do not overlook leading female scientists like Martha Chase and Rosalind Franklin. Seeing females as leading scientists in their classes and textbooks will encourage students to pursue science and see that their gender is not important if they wish to become scientists.

Evaluation of the Online Materials

Research question 2. How do supplemental online materials align with TTKB criteria?

With the emergence of Covid-19 pandemic in 2020, the online materials have become increasingly important. As almost all schools around the world opted for emergency remote teaching, online materials have become invaluable. One of the problems teachers faced during remote teaching was not having access to digital teaching materials (Kusumadewi et al., 2021). Thus, online teaching showed that only the textbooks are not enough to make sure that the students are learning the subject. Hence, the online materials provided with the textbooks were evaluated as a part of this study. There is a wide range of online materials available to the students. To start with, the online materials for the MoNE textbooks can be accessed with the QR code provided on the textbooks. However, the activities for the Grade 10 textbooks could never be reached while the activities of Grade 12 textbooks could

only be sometimes reached. This is a big problem in terms of helping students since they cannot reach activities whenever they want. However, this might be due to the high demand for the MoNE website since it is used by public schools during online teaching. Although not having access to online materials is unacceptable, it is understandable given the extraordinary situations we are in. Another very important point about the online materials provided with MoNE textbooks is that there are some mistakes in the questions. There are no mistakes in the questions in the textbooks. This suggests that maybe the online materials were not gone through thorough editing as the written textbook. Therefore, the students must be aware of these issues while solving the questions on their own. In addition, the online materials provided by MoNE Grade 12 textbook are identical to the activities in the written textbook. This suggests that the online materials of the MoNE textbooks were not designed for independent learning of students. The students already have access to these activities in their textbooks. Considering all these, the online activities might have been designed to be used in the classrooms having teachers guide the students through the activities instead of students learning on their own. All in all, even though it seems that there are many resources available for the MoNE textbooks, some cannot be reached, and the rest are arguably not very useful.

Online materials provided with the Oxford University Press Textbook could be reached through another website, where the students needed to register to get access. That means that the students should pay for both the textbook and the online materials separately, which is an issue that should be considered by teachers when deciding on whether to use this textbook or not. Nevertheless, the students can freely access the answers to all questions, both in-chapter and end-of-chapter. All things considered, the online materials provided by Oxford University Press textbook can

be considered as a companion to the textbook, with an emphasis on having answers to the questions.

Similar to Oxford University Press Textbook, the online materials provided with the Cambridge University Press Textbook are also reached through a website. However, these materials are free, needing just a registration. However, the online materials changed in Spring of 2020, before the end of the school year. This would have been confusing to both the students and the teachers. It would have been better to wait until the school year ends to change the online resources to make the transition easier for students and teachers.

Nature of Science

Research question 3. To what extend is the Nature of Science addressed in these genetics-related chapters?

The final part of the study involved the evaluation of how Nature of Science (NoS) is introduced in the textbooks. The framework modified by Lee in 2007 is used to reach the objective. In the framework, it is stated that there are four categories of NoS. For a balanced introduction of NoS, all four of these categories should be represented equally (Lee, 2007). Nevertheless, none of the textbooks had a balanced introduction of NoS. The two MoNE textbooks are very similar to each other. In both of the textbooks, most of the units are classified into Category 1. This suggests that most importance is given to knowledge production, and relaying information in MoNE. Similar results can be seen in a 2020 study by Duruk and Akgün who evaluated NoS representation of middle school Science textbooks in Turkey. This study revealed that the most represented aspect of NoS in biology topics are the scientific. Similar to the current study's findings, it appears that

MoNE's approach to NoS is mostly making sure that the students are familiar with scientific concepts rather than the process of creating those scientific theories.

On the other hand, NoS introduction is much more balanced in both IBDP textbooks. Oxford University Press Textbook is the only one that has a unit classified into Category 2. The unit that is classified into Category 2 is a question, encouraging students to think about the scientific process and the consequences of science. Most of the units are classified into Category 3, meaning that the NoS boxes in this textbook generally explain how science progresses, the scientific way of thinking and the works of scientists. Finally, in the Cambridge University Press Textbook the number of units classified into Category 1 and Category 3 is almost the same, 22 and 21 respectively. This suggests that the textbook tries to convey scientific knowledge while explaining how that knowledge is acquired. In all four of the textbooks, some units are classified into Category 4, although the number is not high in none of the textbooks. This suggests that while the connection between science, technology and society is mentioned, much importance is not given to this aspect of Nature of Science. These findings are in line with current literature. Abd-El-Khalick et al. (2017) evaluated textbooks published in a span of more than 40 years. Their results showed that in the biology textbooks they evaluated, generally NoS representation is focused on empirical data, scientific laws and scientific theories. Despite some information about NoS in textbooks, there remains a need for improving how NoS is represented in biology textbooks worldwide.

Implications for Practice

Textbooks are an essential part of teaching. Choosing the best-fitting textbook to the needs of the teachers and the students in the classroom is invaluable. This study compares four textbooks that are frequently used in Turkish high school

classrooms and is a thorough evaluation of the textbooks. Hence, the findings can be used as a guide for teachers who need to decide for the upcoming school year. Teachers can use the results of this study to see the similarities and differences between textbooks. They can decide if the textbook they are considering to use is suitable to their and their students' needs.

Moreover, students can also benefit from the findings of this study if they are looking for ways to extend their studies. For example, in many schools, all four of these textbooks are available in the library. Using the findings of this study, the students can choose which additional source is best for their needs. Generally, there is only one textbook used in classrooms and the students are required to follow only one textbook. However, different textbooks have different advantages, and the students can use different textbooks to enhance their learning. Thus, they can use the findings of this study to decide which parts of different textbooks they should use as additional sources.

In addition, this study shows the shortcomings of all four textbooks. Using the findings of this study, teachers using one of these textbooks in their classrooms can make changes to their teaching to make sure that the students are benefiting as much as they can from the textbook. They can also get ideas from other textbooks evaluated in this study and combine two textbooks for their teaching.

Furthermore, due to the Covid-19 pandemic, education has shifted to emergency online learning almost globally. This resulted in a sudden realization that students need to be responsible for their own learning and be more proactive with their studies. Even before the pandemic, the difficulties of online learning were known. A study published in 2014, surveyed 1142 students over three years. Their results showed that students had to be responsible for their own learning, they are

learning at their own pace; in addition, they need to be intrinsically motivated during online teaching (Lewis et al., 2014). Hence, students who are looking for ways to increase the efficiency of their online teaching will surely benefit from this study. They can understand what the advantages and disadvantages of the textbook their teacher has chosen for them are and adjust their learning strategies accordingly.

Moreover, this study used the criteria published by TTKB. Even though these criteria were originally published for MoNE textbooks, it is important to see if the IBDP textbooks also comply with the criteria since these textbooks are used in Turkish classrooms, in schools accredited by MoNE. Thus, they should still follow the rules of MoNE. This study shows to what extent these two IBDP textbooks are aligned with the required criteria. Thus, the findings can be beneficial for administrators since they are the ones primarily responsible for what is used in their schools. As the needs of each school is different from one another. Hence, administrators should be aware of the properties of the textbooks. So, they can use this study as a guide to decide if the textbooks they are considering is suited to their school and if it is in line with the regulation their school must follow.

Finally, textbook publishers can also benefit from this study. It shows the parts of the textbooks that do not fully meet the criteria. The publishers can use the shortcomings pointed out in this study to improve upcoming editions of their textbooks.

Implications for Further Research

The study evaluated four biology textbooks: two MoNE and two IBDP. However, there are other IBDP textbooks available, so they can also be used for comparisons in future studies. Moreover, there is a special Science High School Biology Textbook published by MoNE, which can be evaluated as well. Increasing

the number of textbook analysis studies could be beneficial for students and teachers since they can have more guidance when choosing the textbook they will use.

In addition, there are other international curricula such as IGCSE and A-Level. Their textbooks can be evaluated in upcoming studies. In other words, the breadth of the study can be extended. This way, many more schools, teachers and students can benefit from these studies.

This study involved only the genetics-related chapters. Even though these chapters give a general view of the textbooks, to have a more comprehensive understanding of the textbooks, more chapters, or even the whole textbook, can be evaluated.

This study evaluated the textbooks theoretically; however, teachers and students are the ones using the textbooks. Thus, their opinions can be included in the study as well. Their experiences from using the textbooks in real classrooms can provide invaluable insights about the textbooks.

Furthermore, the questions and the objectives in the chapters can be evaluated according to the Bloom's Taxonomy. Both MoNE and IBDP curricula state that their teaching model is student-centered with students being responsible for their own learning. Hence, seeing if their objectives and questions asked in the chapters matches their goals.

Finally, the curriculum for IBDP changes periodically, resulting in new textbooks every time the curriculum changes. New evaluations can be made with the new curriculum and the new textbooks. Similarly, MoNE also publishes new textbooks at the beginning of each school year and a new curriculum once every several years (there is no set time for a new curriculum for MoNE). So this

evaluation can be done at the beginning of each year to make sure that the textbooks MoNE publish still meet the criteria.

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Appendix A

Checklist of TTKB Criteria for the Evaluation of Textbooks' Contents

Y/N: Yes/ No. The answer should be YES

Y/**N:** Yes/No. The answer should be NO

Before reading:

1. Look at the cover
    a. Is it related to Biology? Y/N
    b. Does it say "Biology"? Y/N
    c. Does it say which year? Y/N
    d. Does it have credentials? Y/N Where?
2. Look at the beginning of the book
    a. Does it have "How to use" section? Y/N
3. Does the book have dictionary? Y/N
4. Does the book have bibliography? Y/N
    a. Is it scientific? Y/N
    b. Try to access some randomly. Can you? Y/N
5. Is there information about authors/publishers? Y/N
6. Look how many hours dedicated for this chapter in the curriculum. Compare it with the length of the chapter (how many pages).
    a. Compare the percentages.
        i. Make sure that you take into account only the text of the textbook. For example, take out the pages for index, dictionary, bibliography etc.

While reading:

1. Try to identify if there is wrong/missing information.
2. Are the objectives met? Y/N
    a. All the objectives in the curriculum should be covered.
3. Look at the examples in the text.
    a. Are they unifying? Equal representations.
    b. Look at male/female representations.
        i. Are the represented equal numbers and also how are they represented? Ex: are all the doctors male/ all the females are moms etc.

4. Check is correct terminology is used. Y/N
    a. Are they used/written correctly? Y/N
5. Is there advertisement of any kind? Y/**N**
6. Check is "Root values" are covered.
    a. These should be implied but not directly stated. They are given below.
7. Are there resources? Y/N
    a. Are those resources scientific? Y/N
8. Check if there is connection to other subjects? Y/N
9. Is the chapter advances as simple-> advanced? Y/N
10. Are there differentiated instruction strategies? Y/N
11. Are the definitions clear? Y/N

Root Values (given by Talim Terbiye):

Justice, friendship, honesty, self-control, patience, respect, love, responsibility, benevolence

After reading:

Questions:

1. Count how many questions are there?
    a. What is their type?
    b. How many in-chapter/ end-of-chapter?
2. Is there an answer key to all the questions? Y/N
    a. Are they on the same page as the questions? Y/**N**
3. Do all the questions meet the criteria? Y/N
    a. The criteria for all types of questions explained below.
4. Check how the end-of-chapter questions arranged. Simple –> Advanced? Y/N

The criteria for questions:

- All the questions should be clear.
- If there is negative statement in the question root, it should be identified clearly (ex: underlining, writing in bold).
- *Short answer questions:*
    - Should test for an important knowledge
    - Should not be taken directly from a known source

    - The question should not contain any clues.
- *Open-ended questions:*
    - Should be limited according to the learning objective being tested.
- *True-false questions:*
    - Should be definitely true or false
    - Should not contain negative statements
    - Each question should test one property.
- *Matching questions:*
    - Longer statements should be used as the premise
    - All the statements should be on the same page
    - Statements in the "Answers" column should have more statements than the "Questions"
- *Multiple choice questions:*
    - Should be clear
        - Should not use statements like "mostly, sometimes, rarely"
    - The wording, length and the coverage of the option should be similar
    - The distractors should be high quality
    - The options should not have ambiguity, should not be conflicting, should be compatible with the question root.
    - The options should be written in capitals
    - The distractors should not be wrong just because they have a misspelling
    - The option should be organized alphabetically (if they are only one word) or either ascending or descending order (if they are numbers)
- *Performance questions (classified or broad-scope):*
    - Should require application rather than knowledge
    - Should be assessable and observable
    - Should used to assess the objectives which require research, information gathering etc.

- Should involve cognitive, sensual and psychomotor skills

Experiments/Activities:

1. What materials are needed?
    a. Are they easily accessible? Y/N
2. Are there safety warnings? Y/N
3. Are there safe/ethical? Y/N

Figures:

1. Count how many figures?
    a. Are they numbered? Y/N
    b. Are the numbers arranged according to the units (ex: for Chapter 1 Figure 1. Figure1.1)? Y/N
2. Is there a mistake in the figures? Y/**N**
3. Do the figures try to eliminate misconceptions? Y/N
4. Do the figures contain old information? Y/N
5. Are there legends of the figures? Y/N
    a. Are the legends the same of the text? Y/**N**
6. Are the figures on the same page as the text? Y/N
7. Are all the figures purposeful? Y/N

Design:

1. Does the book meet the criteria? Y/N
    a. Letters larger than 10pt? Y/N
    b. Capitals letters used for emphasis? Y/**N**
    c. Spacing between the paragraphs larger than line spacing? Y/N
    d. Justified? Y/N

Appendix B

Additional Evaluations of the Textbooks

As a part of this study, the criteria published by Talim Terbiye Kurulu Başkalığı [Turkish Board of Education] (TTKB) was used to evaluate the contents of the textbooks. The genetics-related findings are reported in Chapter 4 and discussed in Chapter 5. However, more evaluations were also done that were not specifically related to genetics but evaluated the overall textbooks. The findings of these evaluation are given in this Appendix.

The Cover

All four of the textbook cover were related to biology. Grade 10 textbook had a frog, two plants, a sea turtle and DNA double helix. Similarly, Grade 12 textbook also has four images: DNA double helix, a swimmer, a plant and an owl. On the other hand, IBDP textbooks both have one image each. Oxford textbook has a parrot and Cambridge textbook has microorganisms. TTKB criteria also suggests that the cover should have the word “Biology” and the grade written it. All four textbooks complied with this criterion, even though the IBDP textbooks do not have the grade written on them, but they have “Biology for the IB Diploma” since there are no grades in the IBDP curriculum and the textbooks will be used for two years.

Book Features

At this step, the presence of a dictionary, how to use page, bibliography, information about authors and publishers are checked. The TTKB criteria suggests that the textbooks should have all of these expect information about the authors. Both of the MoNE textbooks had all four of these, although having information about the authors is against the criteria. Their names are given at the first page. The Oxford textbook did not have a dictionary (there is an index page) and the Cambridge

textbook did not have a bibliography (these is an acknowledgements page at the end of the book). The bibliographies in the MoNE textbooks are scientific whereas that of IBDP textbooks are not. (Table 4)

Table 4

General features of the textbooks

	Grade 10	Grade 12	Oxford	Cambridge
How to Use	✓	✓	✓	✓
Dictionary	✓	✓	×	✓
Bibliography	✓	✓	✓	×
Information about authors	✓	✓	✓	✓
Information about publishers	✓	✓	✓	✓

Advertisements

The TTKB criteria clearly states that there should not be any advertisements in the textbooks. All four textbooks comply with this criteria; none of them have any advertisements.

Resources

According to the TTKB criteria, the scientific resources should be present in textbooks. In both of the MoNE textbooks, the resources are given at the end of the books. They are scientific. The resources include every possible aspect of the books, including the the URLs for the webpages, and every image from every chapter in the book. On the other hand, the resources of the IBDP textbooks were not scientific.

Design of the textbooks

In the final step of this stage of the study. The general design of the textbooks was evaluated. TTKB suggest that all text should be larger than 10pt, capital letters should not be used to emphasize, the spacing between the paragraphs should be bigger than that of lines and the text should be justified. All four of the textbooks have different designs. The only book that complied fully with the TTKB criteria was Grade 12 textbook. Table 5 shows the details for all four of the textbooks.

Table 5

Design of the textbooks

	Grade 10	Grade 12	Oxford	Cambridge
Letters bigger than 10pt	✓	✓	✓	✓
Capital letters to emphasize	×	×	×	×
Spacing between paragraph larger	×	✓	✓	×
Justified	✓	✓	×	×