COMPARATIVE ANALYSIS OF BIOLOGY TEXTBOOKS WITH REGARD TO CELLULAR RESPIRATION AND PHOTOSYNTHESIS

A MASTER'S THESIS

BY

TUĞBA İNANÇ GÖK

THE PROGRAM OF CURRICULUM AND INSTRUCTION

BILKENT UNIVERSITY

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To my beloved son

COMPARATIVE ANALYSIS OF BIOLOGY TEXTBOOKS WITH REGARD TO CELLULAR RESPIRATION AND PHOTOSYNTHESIS

The Graduate School of Education

of

Bilkent University

by

Tuğba İnanç Gök

In Partial Fulfilment of the Requirements for the Degree of

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Tuğba İnanç Gök

October 2012

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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Supervisor: Prof. Dr. M. K. Sands

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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Director: Prof. Dr. M. K. Sands

ABSTRACT

COMPARATIVE ANALYSIS OF BIOLOGY TEXTBOOKS WITH REGARD TO CELLULAR RESPIRATION AND PHOTOSYNTHESIS

Tuğba İnanç Gök

M.A., Program of Curriculum and Instruction

Supervisor: Prof. Dr. M. K. Sands

October 2012

The topics of cellular respiration and photosynthesis in the International Baccalaureate Diploma Programme (IBDP) and Ministry of National Education (MEB) biology textbooks were analysed and compared with regard to content, presentation and learning strategies by using content analysis as a research method. Interviews were conducted with five practising biology teachers.

Both textbooks follow a general to specific (deductive) order in the topics and have similar features in terms of readability and typography. The assessment strategies of neither textbooks focus on measuring higher order cognitive levels.

The differences between the two textbooks are prominent in the content, presence and absence of major themes, number of student-centred activities, real life connections and use of technology. The MEB textbook had more comprehensive content but with many details which were not appropriate for the students' level. While the IBDP textbook included all major themes in the two topics, the MEB textbook lacked some important ones. The MEB textbook is richer in terms of

student-centred activities, experiments and real life connections. The IBDP textbook is richer in terms of technology. The findings of the content analysis were supported by the ideas of the practising teachers.

Key words: Biology textbooks, biology curriculum, comparative analysis, content analysis, International Baccalaureate Diploma Programme, IBDP, Ministry of National Education, MEB.

ÖZET

BİYOLOJİ DERS KİTAPLARININ HÜCRESEL SOLUNUM VE FOTOSENTEZ KONULARI BAKIMINDAN KARŞILAŞTIRMALI ANALİZİ

Tuğba İnanç Gök

Yüksek Lisans, Eğitim Programları ve Öğretim
Tez Yöneticisi: Prof. Dr. M. K. Sands

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İçerik analizi yöntemi kullanılarak Uluslararası Bakalorya Diploma Programı (UBDP) ve Milli Eğitim Bakanlığı (MEB) biyoloji ders kitaplarındaki hücresel solunum ve fotosentez konuları içerik, sunuş ve öğrenme stratejileri açısından analiz edilmiş ve karşılaştırılmıştır. Beş biyoloji öğretmeniyle röportajlar yapılmıştır.

Her iki kitap da hücresel solunum ve fotosentez konularının öğretilmesinde genelden özele doğru bir sıra izlemektedir. Okunabilirlik ve yazım özellikleri bakımından her iki kitap benzer özelliklere sahiptir. Ayrıca her iki ders kitabının da değerlendirme stratejilerinin üst düzey bilişsel seviyeleri ölçmeye odaklanmadığı sonucuna varılmıştır.

İki kitap arasındaki farklılıklar içerik, biyolojinin başlıca temalarının varlığı, öğrenci merkezli aktivitelerin sayısı, gerçek hayat bağlantıları ve teknolojinin kullanılması durumlarında göze çarpıyor. MEB biyoloji ders kitabının içerik açısından UBDP kitabına göre daha fazla konuyu daha ayrıntılı bir şekilde içerdiği ortaya çıkmıştır.

Ancak, bu fazla ayrıntılı içeriğin öğrencilerin seviyesine uygun olmadığı sonucuna varılmıştır. UBDP biyoloji kitabının biyolojinin başlıca temalarının tümünü içerdiği görülürken, MEB kitabının bazı temaları içermediği görülmüştür. Ayrıca MEB ders kitabının öğrenci merkezli etkinlikler, deneyler ve gerçek yaşam bağlantıları açısından UBDP kitabına göre çok daha zengin olduğu görülürken UBDP kitabının teknoloji açısından MEB kitabından önde olduğu görülmüştür. Ayrıca, çalışma bulgularının birçoğu öğretmen görüşleriyle desteklenmiştir.

Anahtar Kelimeler: Biyoloji ders kitapları, biyoloji müfredatı, içerik analizi, karşılaştırmalı analiz, Milli Eğitim Bakanlığı, MEB, Uluslararası Bakalorya Diploma Programı, UBDP.

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CHAPTER 1: INTRODUCTION

Introduction

Textbooks have a crucial role in the teaching and learning process in many classrooms. Although technology has a great place in our life and in education, textbooks still protect their place because of their availability and ease of use. Many researchers have claimed that "textbooks are the most frequently used instructional materials for students and teachers at all grade levels" (Florida University Department of Education [FLDOE], 2008, p. 12). Especially in science, what is taught and how it is delivered is under the influence of textbooks (Wang, 1998).

Among all instructional materials, textbooks have a dominant place in science education. Biology textbooks especially help students to repeat the lesson at home or to study before the lesson. Therefore, a textbook must be understandable to students, appropriate for self-study and include accurate information. Biology contains many scientific terms and much abstract knowledge. In order to encourage students to understand biological concepts, prevent memorization and increase their knowledge, textbooks must contain relevant illustrations attractive to students and activities to stimulate critical thinking skills and scientific inquiry. Textbooks must also include accurate content aligned with the curriculum requirements because many teachers use them as the curriculum. Hence, it is vital for teachers to analyse the available textbooks critically before choosing one.

In this study, the current grade 10 biology textbook approved by the Ministry of National Education (MEB) in Turkey was analysed and compared with one of the International Baccalaureate Diploma Programme (IBDP) biology textbooks with

regard to how each presents cellular respiration and photosynthesis. The analysis was conducted in terms of content, presentation and learning strategies.

Background

Textbook analysis

Textbook analysis is a popular research area all around the world because high quality teaching is dependent on "the availability of high quality and appropriate resources" (Association for Science Education [ASE], 1998, p. 236). What makes a textbook highly qualified is a complex issue and depends on the subject area and curriculum requirements. Before describing the features of a high quality textbook, the functions of textbooks in the science classroom need to be understood.

The main function of science textbooks is to support teachers and learners in the learning process (Litz, 2001; Swanepoel, 2010). Textbooks support teachers by aiding day-to-day planning and teaching, and long term professional development. The functions of the textbook in student learning are comprehensive and varied. The following functions are identified by Mikk (2000, p. 17) in their support of students in their learning:

- motivate students to learn
- represent information (transform and systemise)
- guide students to acquire knowledge
- guide students to acquire learning strategies
- aid self-assessment
- differentiate
- facilitate value education. (As cited in Swanepoel, 2010)

Textbooks should exhibit certain characteristics to fulfil the functions above. The presence and absence of these characteristics determine the quality of textbooks. In the criteria created by FLDOE (2008) these characteristics are categorized under

three headings: content, presentation and learning strategies. These detailed criteria were constructed, after examining many textbook evaluation models, by considering all the functions of good quality textbooks and their didactical aspects. Furthermore, the criteria were developed to evaluate instructional materials which were based on a constructivist approach. These criteria are also appropriate for evaluating the instructional materials of the International Baccalaureate Diploma Programme (FLDOE, 2008).

MEB Biology curriculum and textbook

In Turkey, secondary school curricula including the biology curriculum were changed by MEB in accordance with constructivist philosophy from the 2004-2005 education year (Fer, 2008). In addition to the principles of social constructivism, secondary school curricula have been influenced by educational strategies of other countries such as the United Kingdom, United States, Singapore, Finland, Holland and Israel (Fer, 2008).

In the light of the developments stated above, the content of the new MEB biology curriculum has been rearranged around learning domains including concepts, theories, and principles of science, encouraging students to make real life connections during the learning process. Moreover, the new arrangements in the biology curriculum provides contexts and environments where students may improve their creativity, innovativeness, entrepreneurship, leadership characteristics, problem-solving and their scientific and critical thinking skills (Support to Basic Education Program (SBEP), 2005). Further, in addition to traditional assessment strategies, the new curriculum requires authentic assessment to test learning outcomes and the learning process (SBEP, 2005).

As one of the functions of textbooks is to aid curriculum implementation (Iszak & Sherin, 2003), textbooks need to be aligned with the recognised curriculum standards. According to SBEP (2005), recent science textbooks have been developed based on a social constructivist learning environment and international standards in pedagogy and didactics. However, research on biology textbook analysis carried out in Turkey showed that textbooks still have problems and do not reflect the requirements of the biology curriculum. It was suggested that biology textbooks need to be rearranged in order to meet the new curriculum requirements and support the learning and teaching process more effectively (Dikmenli & Çardak, 2004; Özay & Hasenekoğlu, 2007; Yeşilyurt & Gül, 2008; Çobanoğlu & Şahin, 2009; Güneş, Dilek, Hoplan & Güneş, 2011). Thus, examining an MEB textbook helps to investigate the current progress of the new curriculum implementation in Turkish biology content as well as the textbook itself.

Current textbook analysis studies showed that biology textbooks have some problems. Incompatibility with the curriculum, misconceptions, deficiencies and inappropriate language level were some problems detected in MEB biology textbooks (Dikmenli & Çardak, 2004; Özay & Hasenekoğlu, 2007; Çobanoğlu & Şahin, 2009). Furthermore, inaccurate content of Turkish science textbooks was considered to be one of the reasons for students' misconceptions in science (Yeşilyurt & Gül, 2008).

IBDP Biology curriculum

In Turkey, the International Baccalaureate Diploma Programme (IBDP) is implemented in twenty-five schools (International Baccalaureate Organization [IBO], 2012 a). IBDP biology is presented under group 4 (experimental sciences)

which explicitly reveals the importance of interdisciplinary studies in the IBDP context. The non-traditional approach of the IBDP biology curriculum emphasizes the importance of scientific inquiry and collaboration during scientific investigations and gives students opportunity to apply, develop and use skills related to biology. On the other hand, although many changes have been made in the biology curriculum for Turkish schools, the traditional approach to biology education remains in place, mainly because of the unchanged assessment strategy of the university entrance exam. The new MEB biology curriculum was shaped by a student-centred philosophy, aiming to educate students in scientific literacy. However, the exam system prevents the application of the curriculum requirements in the classroom.

In IBDP schools in Turkey, students who want to take IBDP also have to meet the requirements of the Ministry of National Education in order to get a high school diploma. As students have to be successful in both the IBDP and the MEB programs integration of IBDP and MEB biology becomes very important. Although there is a large degree of overlap between the IBDP and MEB biology curricula in terms of content, still their distinct philosophies and the reflection of these philosophies in the textbooks are worth examination and comparison.

Problem

In general, textbooks should be prepared according to instructional objectives and show the aims of the related curriculum. However, in Turkey, research on textbook analysis has shown that textbooks do not align with the constructivist approach of the new biology curriculum (Çobanoğlu & Şahin, 2009). Inaccurate content, inappropriate readability level, irrelevant visuals with low resolution and lack of student-centred activities are some problems detected in Turkish biology and science

textbooks (Dikmenli & Çardak, 2004; Köse, Ayas, Coştu & Karamustafaoğlu, 2004; Kete & Acar, 2007; Özay & Hasenekoğlu, 2007; Çobanoğlu & Şahin, 2009).

In addition to the above, there are some biology concepts difficult to understand for students. Cellular respiration and photosynthesis are difficult topics to teach and learn because of their interdisciplinary nature including complex biochemical pathways and abstract concepts (Finley, Stewart & Yarroch, 1982; Stavy, Eisen & Yaakobi, 1987; Waheed & Lucas, 1992). Moreover, previous biology textbook analysis research carried out in Turkey detected many problems in the presentation of these topics (Köse *et al*., 2004).

There is little literature on the comparison of the MEB biology textbook with textbooks of other countries. In this study, the presentation of cellular respiration and photosynthesis in the IBDP and MEB biology textbooks was evaluated and compared in terms of content, presentation and learning strategies.

Purpose

The purpose of this study is to evaluate and compare the MEB biology textbook and the IBDP biology textbook. It focuses on how they present photosynthesis and cellular respiration from the perspectives of content, presentation and learning strategies. The study uses content analysis as a research design, and triangulates the findings with the ideas of practising teachers who use these textbooks in their classrooms.

Research questions

This study aimed to answer the following research questions:

1. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *content* (alignment with curriculum requirements, levels of treatment, accuracy of content, and authenticity of content)?

2. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *presentation* (organization of instructional materials, readability of textbook and ease of use)?

3. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *learning strategies* (motivational strategies, teaching a few big ideas, explicit instruction, guidance and support, active participation of students, targeted instructional and assessment strategies)?

4. What are the opinions of practising teachers who use the IBDP and MEB biology textbooks in their classroom about the content, presentation and learning strategies of the two textbooks?

Significance

The findings of this study are expected to show how the MEB textbook and the IBDP textbook reflect biology curriculum requirements and the quality of content, presentation and learning strategies of the textbooks regarding cellular respiration and photosynthesis. By using these well-developed criteria the presence and absence of characteristics were examined and the quality of the two textbooks from different programs was compared for the first time.

Although some reforms were made in the curriculum in Turkey, PISA results indicate that there are still some gaps in achievement. To examine alignment of the curriculum with the textbook content and presentation may suggest why the achievements of Turkish students' are lower than those from other countries, since textbooks are the most commonly used instructional materials in Turkish classes and they are used as the curriculum itself by many teachers. This topic has also inspired many textbook analysis research studies in Turkey.

Another significant aspect of this study is the chosen topics. Cellular respiration and photosynthesis were chosen because they are regarded as difficult topics for students due to the complex biochemical pathways, abstract nature of processes and the multitude of details that they include (Finley *et al.*, 1982; Köse & Uşak, 2006; Patro, 2008). They are also regarded as important sections of the curriculum as every year in the university entrance exam two questions out of only 13 (15 %) biology questions (one cellular respiration and one photosynthesis questions) are asked. However, previous research showed that there were some problems in the presentation of these topics in the MEB biology textbooks. Therefore, it is useful to analyse the current situation of these topics in the MEB biology textbook and to compare how they are presented in an international textbook and curriculum.

Due to the limited literature comparing Turkish biology textbooks with other countries or programs, the findings of this study can make a contribution to the current literature by presenting similarities and differences between national and international textbooks and curricula.

Finally, the findings of this study about the weak and strong points of the two textbooks and differences and similarities of their content, presentation and learning strategies can give useful information on how to select textbooks.

Definitions of key terms

The International Baccalaureate Diploma Programme (IBDP)

The International Baccalaureate Diploma Programme (IBDP) is a pre-university programme for students aged sixteen to nineteen (IBO, 2002). It is a comprehensive two-year international curriculum, available in English, French and Spanish. IBDP generally allows students to fulfil the requirements of their national education systems (IBO, 2002). The grading system of the IB Diploma programme is criterion-based. The programme is represented by a hexagon shape with six subject groups (language A1, second language, individuals and societies, experimental sciences, mathematics and computer science, the arts) surrounding three core requirements namely Theory of Knowledge (TOK), extended essay (EE) and creativity, action, service (CAS) (IBO, 2002).

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

The purpose of this literature review is to provide background information and context about the research. It will discuss the philosophy of biology education in the IBDP and MEB context, the role of textbooks in science education, the features of effective science textbooks, learning difficulties of cellular respiration and photosynthesis topics and review research on textbook analysis and evaluation.

Textbooks are one of the most important resources used for teaching and learning science in schools. Teachers and students consider textbooks as essential in studying science (Harms & Yagar, 1981). Textbooks are tools which have to be improved and updated according to changes in educational programs, curricula and recent scientific knowledge.

Research on textbook analysis has been conducted frequently (throughout the history of education) in order to investigate the quality of instructional materials for effective learning (Wang, 1998). Although content analysis has been used as a common methodology for textbook studies, there are no standard guidelines or rules for conducting content analysis. Conceptual frameworks were constructed based on the purpose of the research and the necessity of national curriculum standards.

According to the literature, a variety of such conceptual frameworks have been used to focus on different aspects of textbooks; subject matter content, the difficulty of the content, readability, the epistemological orientation of the text, and visual materials (Koulaidis & Tsatsaroni, 1996). One common conceptual framework used for analysing the content of science textbooks is in terms of the nature of science and

scientific literacy (Wilkinson, 1999; Chiappetta & Fillman, 2007). Pedagogical analysis of science textbooks can also be done by using a framework focused on the organization of content and the presentation of textbooks (Koulaidis & Tsatsaroni, 1996).

Characteristics of biology education in the IBDP and MEB contexts

Textbooks reflect the characteristics of the curriculum that they are written for. The content of a textbook must align with the standards and benchmarks of the curriculum for that subject area. Each textbook must be compatible with instructional objectives, the scope and learning outcomes of the related curriculum or program. In this textbooks analysis study, textbooks of the two different curricula were analysed and compared directly. At the same time the philosophies and requirements of the curriculum and program that they belong to were indirectly analysed and compared.

It is therefore essential to consider and investigate the characteristics of the IBDP and MEB curricula in terms of expectations from students, standards in learning biology, assessment strategies and expected teaching routines because these features affect content, presentation and learning strategies of the textbooks. This section considers the differences and similarities of educational philosophies between the two different programs, and the aims and nature of the biology content within them.

Biology in the International Baccalaureate Diploma Programme

The International Baccalaureate Organization (IBO) defines itself as an "international non-profit educational foundation" (IBO, 2012a). The IBO offers three international programmes which are offered in schools in Turkey. These three programmes aim to "help students develop the intellectual, personal, emotional and

social skills to live, learn and work in a rapidly globalizing world" (IBO, 2012a). There are 28 IB schools in Turkey, 25 of them offer IB Diploma Programme (IBDP) which is for students aged 16-19. Four of them offer Middle Years Programme (MYP) which is for students aged 11-16 and eight offer Primary Years Programme (PYP) which is for students aged 3-12 (IBO, 2012b). Whereas PYP and MYP are not optional in that all students in a school will follow the programme, IBDP in most Turkish schools is optional for the students.

The common point of those three programmes is the IB learner profile. In the IB learner profile, there are 10 attributes for IB learners namely: inquirers, knowledgeable, thinkers, communicators, principled, open-minded, caring, risk-takers, balanced, reflective. These attributes are very important because according to IBO, international-mindedness is directly related to these attributes (IBO, 2012 a).

The International Baccalaureate Diploma Programme (IBDP) is a two-year challenging programme for secondary school students between the ages of 16-19 (IBO, 2012 b). The IBO states that pragmatism, idealism and pedagogy are three forces that shaped the initial development of diploma programme (IBO, 2009).

The IBDP is structured around a hexagon shape with six subject groups which surround the three core concepts: Extended Essay (EE), Theory of Knowledge (TOK) and Creativity, Action, Service (CAS). The Extended Essay is a four-thousand-word paper which is written as a research project in an area chosen by the student. Theory of Knowledge is an interdisciplinary course which helps students consider different ways of knowing and the nature of knowledge by stimulating a philosophical cast of mind (IBO, 2002). Creativity, Action, Service is an extracurricular requirement that helps students learn through a range of artistic,

sporting, physical and service activities (IBO, 2007). Biology is studied under Group 4 of the IBDP hexagon. Group 4 refers to the experimental sciences and includes biology, chemistry and physics. Students are expected to achieve the following set of objectives for all the experimental science courses:

> 1. Demonstrate an understanding of:
>   a) scientific facts and concepts
>   b) scientific methods and techniques
>   c) scientific terminology
>   d) methods of presenting scientific information.
> 2. Apply and use:
>   a) scientific facts and concepts
>   b) scientific methods and techniques
>   c) scientific terminology to communicate effectively
>   d) appropriate methods to present scientific information.
> 3. Construct, analyse and evaluate:
>   a) hypotheses, research questions and predictions
>   b) scientific methods and techniques
>   c) scientific explanations.
> 4. Demonstrate the personal skills of cooperation, perseverance and responsibility appropriate for effective scientific investigation and problem solving.
> 5. Demonstrate the manipulative skills necessary to carry out scientific investigations with precision and safety. (IBO, 2007, p. 10)

In addition to the set of objectives above, the biology course specifically aims to:

> develop an ability to analyse, evaluate and synthesize scientific information as well as developing experimental and investigate scientific skills, engender an awareness of the need for and the value of, effective collaboration and communication during scientific activities, raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology, stimulate and challenge students by providing opportunities for scientific study and creativity within a global context. (IBO, 2007, p. 9)

Students can choose to study biology at standard level (SL) or higher level (HL) according to their interest and skills. The recommended teaching hours for SL are 150 and for HL are 240 hours. Thus, HL level biology is studied in greater depth and breadth than SL biology. “At both levels, many skills are developed, especially those

of critical thinking and analysis" (IBO, 2007). The relationships between structure and function, universality versus diversity, equilibrium within systems and evolution are the main biological concepts that unify various topics are considered as important themes that need to be understood by students.

The biology course has three sections: the core, additional higher level (AHL) materials and options. A core curriculum is studied by both SL and HL students and this core curriculum is supplemented by the study of options. Students at HL also study additional higher level (AHL) material. Students at both SL and HL study two options. There are three kinds of options: those specific to SL students, those specific to HL students and those that can be taken by both SL and HL students (IBO, 2007).

The hours required for spending of practical/investigative work are 40 hours for students at SL and 60 hours for students at HL. This includes 10 hours for the group 4 project. Students are expected to perform challenging practical work such as designing experiments which require scientific inquiry and critical thinking skills. As in all the IBDP sciences, biology students are expected to participate in an interdisciplinary project which requires group work and is known as the group 4 project (IBO, 2007). Here, students are not only assessed by how well they combine the three sciences in their project, also how well they engage in team work.

The assessment statements are statements that represent IBDP objectives that students are expected to achieve. Each assessment statement is expressed by a command term. Command terms are found in the objectives part of the curriculum and students need to be aware of what each command term means because they are used in the examination (IBO, 2007).

In the IBDP both formative and summative assessments have a place. During the two-year period, students are assessed by their teachers with traditional paper pencil tests and exams, designing experiments, and group 4 projects in terms of formative assessment. For biology SL and HL the teacher also has to submit records and grades in the internal assessment of the students' practical work for 24 % of the final mark. At the end of the two-year; external assessment is done by the IBDP centre. Students are assessed by three written papers for 76 % of the final mark. Paper 1 consists of multiple choice questions that test the knowledge level. Paper 2 and Paper 3 consist of several short answer and extended response questions and aim to measure higher order thinking skills as well as knowledge level. The application of mathematics has a place in the IBDP examination and students may use calculators in Paper 2 and Paper 3.

IBDP teachers plan their two year program themselves according to class level (SL or HL). They decide how they present practical work, and when and how they assess students in terms of internal assessment. Thus, IBDP teachers are allowed to change the order of the topics. In other words, teachers do not have to follow the order in the biology curriculum content; they can change the order of the topics according to the two-year course outline that they prepare.

Biology in the Ministry of National Education context

In Turkey, the Ministry of National Education (MEB) is responsible for all aspects of the school curriculum from grades 1 to 12. At the end of the grade 12, students have to enter the centralized University Entrance Examination prepared and assessed by Measurement, Selection and Placement Centre (*Öğrenci Seçme ve Yerleştirme Merkezi* [ÖSYM]), and there is no other opportunity for them if they want to study in

a university in Turkey. This traditional paper-pencil exam consists of multiple choice questions.

During the past decade, the Ministry of National Education has instituted educational reforms in order to develop its curriculum. As stated in Chapter 1, the new curriculum was shaped through the Social Constructivist Learning Approach (SCLA) (TTKB, 2008). The task design of the new curriculum is learner-centred, and teaching strategies are based on direct instruction and questioning.

There are some key principles of learning in the Social Constructivist Learning Approach that separates it from the former education system in Turkey. Active learning is one of them and refers to the construction of knowledge by means of physical and mental activities and actively engaging with learning activities (Gibbons, 2003; Jones & Southern, 2003). Problem solving exercises, doing projects, having real-life experiences, story-writing and story-telling, developing newspapers, searching, researching, doing experiments, developing puzzles, playing games, role playing, inquiring, analysing and synthesizing are some actively engaging activities that are suggested in social constructivist learning (Fer, 2008). Collaborative learning which means constructing knowledge by cooperation with peers (Gagnon & Collay, 2001) is another key principle in SCLA.

Still within the borders of the social constructivist learning approach, the centralized Turkish high school biology curriculum has been shaped with the idea that "every individual can learn biology and can be successful in biology by enjoying it" (*Talim Terbiye Kurulu Başkanlığı* [TTKB], 2008). The aims of the biology program are to:

- raise students who understand the nature of science,
- develop ideas on the contributions of science and biology to culture,

- have the necessary knowledge, skills, attitudes and values for understanding nature,
- use biological knowledge in real life problems,
- be aware of how to protect and maintain biological richness. (p. 3)

In the new curriculum student-centred tasks are designed to "stimulate learners' research desire and natural curiosity, encourage students to cooperate, work together to see and to understand the views, different interpretations and solutions of other students, encourage students to integrate, create and use knowledge and concepts, as well as allow transfer in new contexts" (TTKB, 2008, p. 20).

In the MEB biology curriculum, six important approaches of the curriculum are stated, namely: scientific literacy, social constructivist learning approach, spiral structure, differentiated instruction, interdisciplinary competencies and parallelism, and authentic assessment (TTKB, 2008). Therefore, both the curriculum and the textbook must be constructed by considering these features.

In addition to objectives and outcomes for each particular topic, the MEB biology curriculum also considers the outcomes of the Science, Technology, Society and Environment (STSE) and the Scientific Investigation and Scientific Process Skills (SISPS) of students (TTKB, 2008). STSE outcomes are one of the most important MEB requirements for biology. Those outcomes aim to have students understand the importance of science in human life, the nature of science and technology, the history of science and relationships between science, technology, society and environment. The outcomes of SISPS include skills such as scientific research-inquiry, using scientific methods in experiment and observation while solving problems and improving decision-making skills.

The outcomes of Communication Skills, Attitude and Values (CSAV) are another concern of the new MEB biology curriculum. They are related with improving attitudes that are considered as higher level attitudes and include awareness, empathy, determination, open-minded, honesty, desire for finding the truth, entrepreneurship, personal and social responsibility, critical thinking and humanity. CSAV outcomes are directly or indirectly compatible with STSE and SISPS outcomes (TTKB, 2008). Whereas STSE and SISPS outcomes are given with the learning outcomes, CSAV outcomes are not given in the outcomes of the topic list.

Assessment of the biology curriculum has changed in line with SCLA and more emphasis is given to formative assessment rather than summative assessment. That is, instead of assessing students by paper-pen exams at the end of the unit or at the end of the year, assessment tools like portfolios, projects, making presentations and group work are used in the assessment of learning. Moreover, peer and self-assessment forms are used at the end of the task to help students reflect on their own performance and to understand the importance of team work and collaboration. Thus, assessment of the MEB biology curriculum includes traditional paper-based assessment as well as performance-based assessment (TTKB, 2008).

However, different from the new performance-based assessment carried out in the biology classrooms, the university entrance exam protects its traditional structure which has been criticized over years because it encourages memorization. Currently the exam is conducted through two sessions in different times. The first session is Passing to Higher Education (*Yüksek Öğretime Geçiş Sınavı* [YGS]) which includes 13 multiple choice biology questions. The second session is Undergraduate Placement Exams (*Lisans Yerleştirme Sınavı* [LYS]) which includes 30 multiple

choice biology questions from the whole high school biology curriculum. Each year at least two questions out of 13 (YGS) and 30 (LYS) from both exams come from cellular respiration and photosynthesis topics, which shows the importance of these topics in the biology curriculum and examination.

The Turkish Board of Education and Discipline (*Talim Terbiye Kurulu Başkanlığı* [TTKB]), is the unit that selects the textbook to be used in biology classrooms. It has textbook evaluation criteria according to five categories; content, organization, glossary, sequence of concepts and terms and bibliography. Textbooks are chosen according to the total points given to the textbooks after using textbook evaluation criteria by the experts from TTKB.

Importance of textbooks in science education

As a dominant instructional material in science education, science textbooks have determined the content of instruction and teaching procedures in thousands of classrooms for decades (Wang, 1998; Chiappetta & Fillman, 2007).

Textbooks provide the foundation for the content of the lesson and represent what is important on a particular topic. In this regard, textbooks should reflect the reform of the curriculum and align with the curriculum requirements.

Besides forming a resource for teachers and learners for the subject, textbooks also enable absentees to cover the work they have missed and give students opportunity to revise the subjects taught in lessons according to their learning speed (Küçükahmet, 2001). Since the textbook reflects the requirements of the curriculum, it also helps to achieve the desired objectives. These features make textbooks indispensable for teachers and students. Therefore, their writing, production, printing and distribution

need to be continuously examined and re-examined in the light of educational objectives.

In addition to serving as one of the most important teaching and learning materials in some situations, the textbook may function as a complement to the teacher's lessons in teaching and learning. Teachers may use textbooks while they prepare their lesson plans, and activities found in textbooks may be used as extra materials.

Science textbooks have a role in the development of a scientifically and technologically literate society (Chiappetta, Sethna & Fillman, 1991). This role can only be achieved by a content which stresses fairly equal proportions of knowledge, investigation, thinking, and the interaction between science, technology and society (Wilkinson, 1999). Therefore, biology textbooks remain useful and efficient devices for learning about living world and related phenomena, offering organized, convenient sequences of ideas and information for teaching and learning.

Although we live in the computer era, many science classrooms have limitations on using information and communication technology (ICT), which makes science textbooks still the most commonly used instructional materials. Results of a survey, in which 254 teachers and 621 students around Turkey participated, indicated that textbooks are the main source of guidance for teachers and students during instruction, audio-visual instructional materials are rarely used in classrooms (Yaman, 1998).

In addition, textbooks help teachers to decide the subject and the depth they should teach (Köseoğlu, Budak & Tümay, 2003). Textbooks are also helpful for teachers who are inexperienced in their areas (Collette & Chiappetta, 1984). In that regard, textbooks are helpful for the teacher in terms of providing homework, guiding

practicals, as keeping students busy if they finish the given task too soon (Wellington, 2000).

"Textbooks are selective in what information is presented and how it is organized; yet they also are tied to the larger ideas with which students will be confronted outside the schoolhouse walls" (Fitzgerald, 2009, p. 38). Kabadere and Bal (2003) indicated that achievement in science education may also depend on the accuracy of content and quality of physical features of textbooks.

In summary, textbooks have an important place in biology education, therefore careful examination and comparison of the available textbooks should be undertaken before selection. In the long run, this should contribute to the development of more effective textbooks.

Features of effective science textbooks

Although features that make a textbook effective differ between subject area and curriculum, textbooks in general must include some universal features. According to the National Research Council (1990) there are seven needs for biology textbooks:

- Adequate but not encyclopaedic coverage
- Factual accuracy
- Incorporation of current conceptual understanding and new subject matter
- Logical coherence
- Clarity in explanation and effectiveness in illustrations
- Appropriateness to students' level and interest
- Representation of biology as an experimental subject. (p. 28)

Similarly according to the FLDOE (2008), effective textbooks must include:

- instructional goals with adaptability to course requirements
- accurate, relevant, and relatively up-to-date information
- well-organized, coherent, and unified flow of information
- appropriate reading level and vocabulary

- effective layout, visual presentation, and physical features
- absence of stereotypes and biases
- multidisciplinary content with multiple rather than single perspectives
- small concepts taught as variations on larger themes
- development of insight and thinking skills rather than just memorization of isolated or unrelated facts
- real-world applications of informational skills
- inclusion of supplemental and reference materials for teaching. (p. 11)

To make scientific terms and abstract knowledge more concrete and understandable, the content of biology textbooks must be supported by relevant and attractive illustrations, real life connections and different types of activities (Blystone, 1989; Pop-Pacurar & Ciascai, 2010). In addition, Ahtineva (2005) concluded that tasks that had a link to real life motivated students.

Cellular respiration and photosynthesis in the learning context

As stated by Barker and Carr (1989, p. 49), "Photosynthesis eminently merits its distinction as the most important biochemical process on earth". The scientific importance of photosynthesis makes it one of the most important topics of the biology curriculum in high schools and middle schools (Marmaroti & Galanopoulou, 2006). Its close relationship with cellular respiration makes them almost inseparable concepts. These two topics are rated as the most difficult topics in biology (Finley *et al*., 1982; Stavy *et al.*, 1987; Waheed & Lucas, 1992). Their difficulty mainly lies in the biochemical pathways and complex transformations that they include, and the fact that they link with many other aspects of the curriculum such as ecology, physiology, biochemistry, conversion of energy and autotrophic feeding (Marmaroti & Galanopoulou, 2006).

Before receiving science education, students develop ideas and misconceptions about scientific processes, particularly for difficult and complex topics (Amir & Tamir,

1994). Since cellular respiration and photosynthesis have a close relationship, especially in plants their processes are confused and cause misunderstanding among students. Furthermore, cellular respiration is frequently used as synonymous with breathing by many students (Seymour & Longden, 1991; Lin & Hu, 2003). Students also have misunderstandings about the reactants and products of cellular respiration and photosynthesis and the necessity and exact role of chlorophyll (Marmaroti & Galanopoulou, 2006).

These topics include chemical reactions between organic and inorganic molecules that are given in chemistry courses. This means that students have to understand the relationship between biology and chemistry (Tekkaya, Özkan & Sungur, 2001), and a lack of knowledge on chemistry may also cause misunderstandings among students.

Students have difficulties in understanding the concept of harnessing the sun's energy during photosynthesis, since very few of them are able to describe the energy transfer occurring during the photosynthetic process and energy transformations (Waheed & Lucas, 1992). Marmaroti and Galanopoulou (2006) concluded that the greatest misunderstanding among students arises from the interrelationship between cellular respiration and photosynthesis: typical misconceptions that have been revealed are that "plants do not respire at all or respire only during the night when there is no photosynthesis" (p. 398). Marmaroti and Galanopoulou (2006) also concluded that the confusion of photosynthesis with cellular respiration has two more aspects: plant respiration is understood as an inverse gaseous exchange compared with that of animals and photosynthesis is understood as a type of respiration.

Köse and Uşak (2006) indicated that even prospective science teachers have misconceptions about the process and nature of photosynthesis and respiration in plants. They give examples such as, "Only green plants can carry out photosynthesis", "Photosynthesis is a gas exchange process", "Respiration in plants occurs only at night", "Respiration in plants occurs only in the leaves", "Photosynthesis is the reverse of respiration", "Plants obtain their food from water", and "Plants' food is water" (p. 32). The difference between scientific language and daily language is stated as one of the main reasons of these misconceptions.

Research on textbook analysis

Some critical research has been carried out in the field of textbook analysis and textbook evaluation in Turkey. Previous studies carried out to analyse MEB high school biology and science textbooks have shown that textbooks have misconceptions, mistakes, errors in figures and organization of topics (Dikmenli & Çardak, 2004; Köse, Ayas, Coştu & Karamustafaoğlu, 2004; Kete & Acar, 2007; Özay & Hasenekoğlu, 2007; Çobanoğlu & Şahin, 2009).

Köse, Ayas, Coştu and Karamustafaoğlu (2004) evaluated the sections on the process of photosynthesis in high school biology textbooks. They concluded that the place of photosynthesis in the textbooks was not appropriate, and there were several mistakes in the content and visuals such as inaccurate information, unrelated diagrams, low resolutions in drawings, incompatibility between texts and visuals. By analysing the presentation of visual materials in 11^{th} grade biology textbooks Özay and Hasenekoğlu (2007) detected some visual problems in MEB high school biology textbooks such as incompatible and inappropriate images.

Dikmenli and Çardak (2004) showed that there were many misconceptions and inaccuracies in the content of the 9th grade biology textbooks which are approved by MEB. By measuring the readability level of the section on the cell in the 9th grade biology textbook, Köse (2009) indicated that the age level was not considered during textbook preparation. Dikmenli, Çardak and Öztaş (2009) detected conceptual problems in MEB science and technology textbooks by using document analysis method.

Çobanoğlu and Şahin (2009) underlined problems in the 10th grade biology textbook approved by MEB. Some misconceptions were found in the textbook. In addition to content analysis, the learning approach of the textbook was evaluated by five senior practising teachers. It was concluded that "10th grade biology textbook of MEB encourages memorization" (p. 86).

Recent studies on the MEB biology textbooks have indicated that much encyclopaedic information is given to the students, and there is a lack of student-centred activities to develop social skills of the students (Ekici, 1996; Akaydın & Soran, 1998; Işık & Soran, 2000). Survey results showed that Turkish teachers found the textbooks inefficient and inappropriate to fulfil requirements of the curriculum (Öztürk, 2003).

There are many studies which are based on comparisons of textbooks of different countries (Morimoto & Maeda, 2002; Ghaderi, 2010; Ghazi, Ali, Shahzada, Khan & Nawaz, 2011; Yıldırım, 2005). Curricula and textbooks of countries that are successful in PISA and TIMMS are good examples for countries that are not successful to improve their instructional materials. Therefore it is useful to compare

and contrast textbooks of such countries with the resources approved by the Ministry of National Education in Turkey.

Conclusion

Due to the curricular arrangements in biology education in Turkey, the textbooks being used in classrooms have undergone some changes in order to be consistent with the new curriculum. It is useful to compare the revised MEB biology textbooks with other textbooks from different programs.

The way cellular respiration and photosynthesis, very important topics in science, are presented in textbooks and the curriculum can cause misunderstandings among students and pre-service teachers. The place of these topics in the biology curriculum and the university entrance examination in Turkey, together with previous textbook analysis findings on the presentation of these topics, make analysis of the current situation (content, presentation and learning strategies) of these topics in the textbooks useful. This analysis may be useful in future development of textbooks.

As a conclusion, analysing textbooks is useful since they are one of the most commonly used teaching and learning materials in schools. Moreover, analysis can lead to the revision of weak points, in order to present better materials for students and teachers.

CHAPTER 3: METHOD

Introduction

In this study, data triangulation was used to answer the following research questions:

1. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *content* (alignment with curriculum requirements, levels of treatment, accuracy of content, and authenticity of content)?
2. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *presentation* (organization of instructional materials, readability of textbook and ease of use)?
3. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *learning strategies* (motivational strategies, teaching a few "big" ideas, explicit instruction, guidance and support, active participation of students, targeted instructional and assessment strategies)?
4. What are the opinions of practising teachers who use the IBDP and MEB biology textbooks in their classroom about the content, presentation and learning strategies of the two textbooks?

Chapter 3 describes the strategy used for analysing the two textbooks based on the criteria (content, presentation and learning strategies), including design of the research, context of the study and the method of data analysis. The method of data

collection to obtain perceptions of practising teachers about the two textbooks and interpretation of this data are also described in this chapter.

Research design

In this research, the data from the two textbook were collected through content analysis. In addition, opinions of teachers were taken by using a semi-structured interview technique to provide a broader perspective which specifically gives data triangulation (Denzin, 2006).

There were two steps. In the first step, both IBDP and MEB biology textbooks were analysed and compared by content analysis according to criteria suggested by Florida University Department of Education (FLDOE) (2008) namely content, presentation and learning strategies. The analysis of textbooks and interpretation of data according to a conceptual framework are directly called content analysis which is a common methodology applied by researchers to examine science textbooks (Wang, 1998, p. 2).

The definitions of content analysis are varied. However, the most suitable definitions presenting a more scientific and systematic approach for analysing the quality of science textbooks, were chosen since they show more clearly the process of this study. Krippendorf (2004) defined content analysis as "a research technique for making replicable and valid inferences from data to their context" (p. 18). What makes the inferences valid and replicable depends on following a clear set of conceptual framework to guide the investigation (Wang, 1998).

In the second step of the study, after completing the content analysis, the opinions of practising teachers about the content, presentation and learning strategies of the two

textbooks were obtained. This was done by semi-structured (the questionnaire contains both open-ended and close-ended questions) interview technique. Interviews were conducted one-by-one and lasted 45-50 minutes. Opinions and comments of the practising teachers were taken in order to support the study by increasing the validity of the data (Guion, 2002).

Gillham (2000) stated that one of the advantages of using semi-structured interviews for supporting content analysis was that content analysis is made relatively easy by identifying substantive statements, recording them, and then asking the respondent to verify their correctness.

Although the qualitative data are the main data of a content analysis, the data of this study were not restricted by qualitative results and results were supported by quantitative data such as the number of outcomes, the number of questions in each textbook, the number of real life connections and experiments, the percentages of objectives and questions according to Bloom's taxonomy cognitive levels, the number of new terms according to their positions in the text, the number of pages devoted for each topic in the two textbooks, readability levels of the two textbooks and the number of visuals.

Context

The topics of cellular respiration and photosynthesis were analysed in the IBDP and MEB biology textbooks and biology syllabi:

Table 1

Textbooks analysed in the study

MEB	Akkaya S., E., Sağdıç, D., Albayrak, O., Öztürk, E., Cavak, Ş., & İlhan, F. (2011). *Ortaöğretim Biyoloji 10*. (pp.1-99). MEB Yayınları.
IBDP	Damon, A., McGonegal, R., Tosto, P., & Ward, W. (2007). *Heinemann Baccalaureate: Biology Higher Level (plus Standard Level Options) for the IB Diploma*. (pp. 69-79, 217-238). Essex, UK: Pearson Education Limited.

The MEB biology textbook used in this study is the one approved by the Ministry of National Education in Turkey (Table 1). However, the selected IBDP biology textbook used in the study was chosen among several IBDP textbooks since it includes both higher level and standard level options and is the one observed by the researcher as the most commonly used IBDP textbook during her training period in the IB schools in Turkey.

In this study, the topics of cellular respiration and photosynthesis were selected for analysis and comparison within the two textbooks. The reason for this is that these topics are considered as difficult by students due to the complex biochemical pathways they include (Finley *et al.,* 1982; Köse & Uşak, 2006). Also the interdisciplinary nature of the topics increases misconceptions among students (Wandersee, 1983; Tekkaya & Balcı, 2003; Driver, Squires, Rushworth & Wood-Robinson, 1994; Köse & Uşak, 2006; Güneş, Dilek, Hoplan & Güneş, 2011).

Instrumentation

For gathering the opinions of practising teachers regarding the obtained data, interviews were used for triangulating the study. Interviews were conducted with five IBDP biology teachers who use both textbooks in their classrooms. Some of the teachers are also academics in a university in Turkey.

The main reason for this interview was to learn teachers' opinion about the two textbooks and the two curricula, and to see how their answers aligned with findings of this study.

To do so, according to the findings obtained from the content analysis part of this study, open-ended and close-ended questions were prepared which were also compatible with the used criteria (Appendix D). The questions enabled teachers to reflect on their opinions about the content, presentation and learning strategies of the two textbooks.

During the interviews, the voices of participants were recorded and notes were taken in front of them. Interpretations of the interviews were shared with the participants if required.

Method of data collection and analysis

The conceptual framework of the study is based on three categories: content, presentation and learning strategies which have been identified by the Florida Department of Education (2008) as three priorities for the evaluation of instructional materials.

The framework was constructed on the basis of comprehensive research which was conducted of all primary sources in the educational field to identify research on evaluating K-12 instructional materials published between 1999 to 2008 (FLDOE, 2008). It is appropriate for evaluating both MEB and IBDP textbooks since it was developed based on the constructivist approach and includes criteria that are compatible with the standards and requirements of both MEB and IBDP curricula. The framework also gives opportunity to evaluate many aspects of an instructional

material under the categories content, presentation and learning strategies. In addition to the FLDOE criteria, to carry out a deeper evaluation of subcategories, articles about each subcategory were used (Soyibo, 1996; Ateşman, 1997; Dikmenli, 2010) and comments about these categories in relation to the two textbooks were made in Chapter 5. Table 2 displays categories and sub-categories of the criteria used.

Table 2

Subcategories of criteria used in this study

Content	Alignment with the curriculum requirements
	Level of treatment of content
	Accuracy of content
	Authenticity of content
Presentation	Organization of the textbooks
	Readability
	Ease of use
Learning strategies	Motivational strategies
	Teaching a few "big ideas"
	Explicit instruction
	Guidance and support
	Active participation of students
	Targeted instructional and assessment strategies

Content

Alignment with the curriculum requirements

While investigating this section in order to see the big picture, and as a first step, the design of the two curricula was represented and summarized in Table 4. Table 4 shows how general organization, aims, task design, pedagogy and assessment strategies of the two curricula differ.

As a next step, to identify the required curriculum standards for biology and the objectives of the topics cellular respiration and photosynthesis in the two curricula,

the IBDP biology curriculum and the MEB grade 10 biology curriculum were examined. The position of cellular respiration and photosynthesis within the curricula, the number of objectives, Bloom's taxonomy cognitive levels of objectives, grade level and time allocated for these topics were investigated and compared.

To see to what extent the content of the two textbooks align with the curriculum requirements and how objectives of the two curricula differ, the objectives of the topics (cellular respiration and photosynthesis) in the IBDP and MEB biology curricula were listed in Tables 5 and 6.

Level of treatment

In this section the level of complexity or difficulty of content of the two textbooks were analysed in terms of appropriateness for the standards of the two curricula, student abilities, grade level, and adequacy of allocated time periods for teaching the subject. To do so, a list of subtopics for each topic which should be covered to make the two topics more meaningful for students was prepared by using different biology textbooks. All of the pages within the two topics in the two textbooks were scanned and a tick (or a cross) was put in Tables 7 and 8 for each subtopic covered. Examples from the two textbooks were used as evidence.

Accuracy of content

To analyse the accuracy of content, all the related pages were read and the texts and the visuals were checked to see if they are factual and objective, free of mistakes, errors, inconsistencies and biases of interpretation or not.

All misleading statements and errors from the two textbooks were written in Table 9 together with recommended definitions. When errors were detected in the visuals, these visuals were scanned and how to make them more accurate was explained.

Authenticity of content

Authenticity of content was evaluated under two categories: real life connections and interdisciplinary treatments. Real life connections from the two textbooks were listed in Table 10, and the comparison was done by considering the numbers of real life connections. Interdisciplinary treatments of the two textbooks were determined and they were compared in terms of the diversity of interdisciplinary connections.

Presentation

In this section, evaluation and comparison of the two textbooks in terms of presentation was made by considering organization, readability and ease of use.

Organization

Here, access to content, visible structure and format, and logical organization of topic and subject, were taken into account. General organizations of the two textbooks were evaluated in terms of containing reference aids such as index, glossary, maps, bibliography, graphic organizers, and pictures.

Organization of subtopics of each topic was listed in Tables 12 and 13 for the two textbooks, and were compared in terms of the logical organization of subtopics, the number of subtopics covered, and the location of assessment tools.

Readability

Language style, typographical presentation and visual features of the two textbooks were examined and compared.

The readability level of the IBDP textbook was determined by using the Word's Flesch reading ease score which is based on the formula developed in 1949 by Rudolf Flesch (Daniels, 1996). Ateşman's Readability formula, which is an adapted version of Flesch reading ease for Turkish texts, was used to measure the readability level of the MEB textbook. These formulae are based on measurements of sentence length and number of syllables, since it is assumed that long sentences and polysyllabic words increase the difficulty of understanding (Daniels, 1996).

The formulae were applied to five randomly selected paragraphs with approximately 100 words for the IBDP textbook (Appendix B). Texts were written to a Word document and the Flesch reading ease scale and the Flesch-Kincaid grade levels were automatically calculated by Word (Stockmeyer, 2009).

Word automatically determined the following data in the given texts and applied the reading ease equation for measuring reading ease and Flesch-Kincaid grade levels:

a) Number of syllables.

b) Number of sentences.

c) The word length (WL) which means average number of syllables per 100 words (NS).

d) The average number of words per sentence (WPS), obtained by dividing 100 words by the number of sentences in the sample.

The Flesch readability score (reading ease, RE) for each text was obtained by using the following equation:

Reading Ease= 206.835 - (0.846 X WL) - (1.015 X WPS).

Since Microsoft word can only calculate readability of English texts, Flesch reading ease and Flesch-Kincaid grade levels for the MEB biology textbook were calculated manually by using the following data and equation for the three randomly selected 100-word paragraphs (Ateşman, 1997, Appendix C):

x_1= average word length as syllables

x_2= average sentence length as words

Reading Ease = 198,825 – (40,175 x_1 – 2,610 x_2)

However, as Collette and Chiappetta (1984) stated, relying solely on readability formulae can be misleading. Those readability formulae are not enough to estimate the difficulty level of a text, since some authors consider them during textbook writing process (Collette & Chiappetta, 1984). Therefore, besides using readability formulae, careful reading of the textbook was done by focusing on the following: grammar, organized coherent text, using active voice rather than passive voice, words with concrete and specific images, print quality, size of page margins, clearness of visuals (Collette & Chiappetta, 1984; FLDOE, 2008). Typographical features of the two textbooks were also listed in Table 15 and the number and the types of the visuals were displayed in Table 16.

Ease of use

In this section, the two textbooks were evaluated and compared in terms of, practicality, durability, cost and guaranteed quality of production.

Learning

To analyse learning strategies of the two textbooks, the study focused on motivational strategies, teaching a few big ideas, explicit instruction, guidance and support, active participation of students and targeted instructional and assessment strategies. Categories and subcategories that were considered to analyse learning strategies are summarized in Table 3.

Table 3

Categories and subcategories for learning strategies

Motivational strategies	Activities relevant to students' life
	Thought- provoking challenges
	Hands-on tasks in a concrete context
	Variety, including the opportunity for students to ask their own questions, set own goals, make other choices during learning
	Varied forms of assessment
Teaching a few big ideas	Develop a deeper and more complete understanding of the major themes of biology
Explicit instruction	Clear directions and explanations
	Exclusion of ambiguity
Guidance and support	Organized routines
	Prompts or hints during initial practice
	Step-by-step instructions
	Immediate and corrective feedback on the accuracy of performance of each step or task, on how to learn from mistakes, and how to reach the correct answer
	Opportunities for students to do research and to organize and communicate results
	Analogies
	Definitions of new scientific terms
Active participation of students	Assignments that are logical extensions of content, goals and objectives
	Assignments that include questions and application activities during learning giving students opportunities to respond.
Targeted instructional and assessment strategies	Types and number of questions
	Cognitive levels of objectives and questions according to Bloom's taxonomy and their compatibility

Motivational strategies

Unquestionably, motivation is a very important classroom component which assists students' learning. Motivational strategies of textbooks are analysed by considering the features in Table 3. Personal or real life connections improve learning. Therefore, textbooks should include tasks which give students the opportunity to make connections with their own life, analyse case studies, and construct their own concept map or analogies. Moreover, a positive climate for learning needs to be supplied, for example some tasks should require students' collaboration and communication, and at the end there should be feedback on students' progress.

Teaching a few big ideas

Big ideas refer to core concepts in science. Core concepts are important themes which unify the sciences (National Assessment Governing Board, 2008). Therefore, "textbooks should include fundamental facts and concepts in major science disciplines" (NRC, 1996, p. 59).

Core concepts related to cellular respiration and photosynthesis were taken from the document prepared by Michigan University: High school science content expectations (HSSCE), a document to present big ideas in science education (Michigan University Department of Education, 2007).

Explicit instruction

In this section the two textbooks were evaluated as to how well they present explicit instruction in order to support learning success. Examples are: clear presentations and explanations of purposes, goals and expected outcomes, concepts, rules, information and terms, models, examples, questions, in order to support learning

success. This part depended on clarity of directions and instructions and the exclusion of ambiguity.

Guidance and support

Textbooks must provide guidance and support which help students become more independent learners and thinkers. Effective guidance and support can be achieved by taking account of the consistency of routines, clear instructions and illustrations, presenting different kinds of activities and questions for different learning styles, animations and analogies, opportunities for practical and experiments and doing research. Therefore, the two textbooks were evaluated on how effectively they guide and support students' learning.

Active participation of students

In this section, the textbooks were investigated according to the physical or mental activities required to complete the topic, such as experiments, classroom discussions, doing research or giving presentations, questions and other assignments.

Textbooks must engage the physical and mental activity of students during the learning process. Textbooks must engage students by a variety of activities such as: responding orally or in writing**,** creating visual representations (charts, graphs, diagrams, and illustrations)**,** generating products**,** generating their own questions or examples, thinking of new situations for applying or extending what they learn**,** completing discovery activities**,** adding details to big ideas or concepts from prior knowledge**,** forming their own analogies and metaphors**,** practising lesson-related tasks.

Targeted instructional and assessment strategies

Targeted instructional and assessment strategies (questions types, tests, and activities) were evaluated based on multidimensional learning in the context of Bloom et al.'s (1964) taxonomy of educational objectives (Vosloo, 2004). Educational objectives of Bloom's taxonomy consist of three categories namely: cognitive, affective and psychomotor. In this study, the cognitive domain of Bloom's taxonomy was defined as a domain which varies from "simple recall of material learned to highly creative ways of combining and synthesizing new ideas and materials, including knowing, comprehending, applying, analysing, synthesising and evaluating" (Bloom, Engelhart, Frust, Hill & Krathwohl, 1956, p. 6). The assessment strategies of the two textbooks were evaluated to determine how well they achieved the targeted learning outcomes.

CHAPTER 4: RESULTS

Introduction

The data of this study were collected through content analysis and interview. By using criteria suggested by FLDOE (2008), the content, presentation and learning strategies of the selected IBDP and MEB textbooks were analysed and compared. Content was analysed according to the alignment with curriculum requirements, level of treatment, accuracy, authenticity of content and if it is up to date. Presentation of the textbooks was analysed according to the organization of instructional materials, readability, pacing of content and ease of use. Finally, the learning strategies of the textbooks were analysed according to the motivational strategies used, teaching a few big ideas, explicit instructions, guidance and support, active participation of students and targeted instructional and assessment strategies (Table 2).

After data analysis, the obtained data were checked by semi-structured interviews with practising biology teachers who use the selected IBDP and MEB textbooks in their classrooms. Interviews lasted 40-50 minutes.

Content

Alignment with curriculum requirements

The content of the two textbooks must align with the curriculum requirements. Since each textbook represents a particular curriculum, the contents of the textbooks must match with the standards of curriculum. IBDP and MEB curricula were therefore examined in order to discover their similarities and differences, thus in the next section after explaining the features of MEB and IBDP curricula in general, the

objectives and requirements of the two curricula with regard to cellular respiration and photosynthesis are given in detail.

Analysis and comparison of the contents of the two textbooks were carried out by considering not only how they present content according to the criteria but also how they reflect the requirements of their own curriculum.

Comparison of the MEB and IBDP curricula with regard to their ideologies and approaches

The selected MEB and IBDP biology textbooks and MEB grade 10 and IBDP biology syllabi were examined in order to see the compatibility between textbooks and curriculum. Table 4 represents the curriculum design of the MEB and IBDP curricula in terms of general organization, aims, content, task design, pedagogy and assessment.

Table 4

Comparison of the MEB and IBDP curricula

Features	MEB	IBDP
General organization	4 year programme (university prep)	2 year programme (university prep)
Aims	Develop the knowledge and skills that are necessary for life. Enable learners to develop moral, ethical, social and cultural issues within their own customs and traditions, and to recognize their country, European Union, and their location in the world. Enable learners to develop themselves as people who know their duties in society and who are in harmony with their environment. Respect differences between learners in personal characteristics, learning styles, and learning potentials.	Enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology. Develop an ability to analyse, evaluate and synthesize scientific information Engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities Raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology
Task design	Learner and learning centred. Encouraged students to cooperate	Student-centred Requires critical thinking and application skills and co-operation.
Pedagogy	Apply basic strategies such as direct instruction, self-instruction, asking questions, helping by asking questions, coaching.	Explicit (curriculum plans, teacher support material), student-centred, in-depth analysis (higher order skills, labs) Process oriented, Constructivist, Connectionist, Skills-based
Assessment	Create assessment as an inseparable part of teaching and learning. Test both learning output and learning process via authentic assessment	Internal and external assessments Extended Essay Group 4 project

The MEB curriculum was designed according to the Social Constructivist Learning Approach (SCLA) (TTKB, 2008). The content of SCLA must offer contexts and environments where students are given opportunity to improve their creativity, innovativeness, entrepreneurship, leadership characteristics, problem-solving,

scientific thinking and critical thinking skills (Fer, 2008). Tasks are designed with regard to the learner and learning-centred ideology.

In the MEB biology curriculum, six important approaches of the curriculum are stated, namely: scientific literacy, social constructivist learning approach, spiral structure, differentiated instruction, interdisciplinary competencies and parallelism, and authentic assessment. Therefore, both curriculum and textbook must be constructed by considering these features.

While in MEB everything about cellular respiration and photosynthesis is covered only in grade 10 (unit 1), in IBDP those topics are covered in three different units which each add more detail to the previous unit. In spite of the fact that MEB defines the structure of the curriculum as spiral, there is no evidence of spiral structure in the curriculum with regard to cellular respiration and photosynthesis.

Although differentiated instruction is another important feature for MEB, we can see little evidence of this feature in its cellular respiration and photosynthesis content. Requirements, objectives and outcomes are the same for all students. Any differing levels of students in biology are not considered, which makes the biology curriculum uniform. However, in the IBDP, students are given the opportunity to take the biology course in standard level or higher level, so that according to their interests, levels and skills students can learn biology in less or more detail.

Differentiated instruction also considers the learning styles of students. From that point of view, the MEB curriculum encourages both textbook authors and teachers to present different kinds of activities and assessment strategies for diverse learners. With that purpose, the MEB biology curriculum presents a variety of examples for possible activities such as experiments, making models, KWL charts, group studies

and concept maps. In addition to traditional paper-pen assessment, the MEB curriculum also suggests examples for authentic assessment, one of the requirements of SCLA, such as creative performance tasks, projects, creating graphs, performing experiments, peer-assessment, self-assessment, making presentations.

Like MEB, the IBDP requires different assessment strategies in addition to traditional paper-pen exams. It encourages students to do investigations (for 30 hours) and work for group 4 projects (for 10 hours) in the two-year period for Standard Level. Investigations include computer simulations, short laboratory practical, field trips, data-gathering and data analysing exercises. The group 4 project is compulsory for all IBDP group 4 students, being an interdisciplinary activity which fosters collaborative learning.

The IBDP aims to develop internationally-minded people who recognize their common humanity and shared guardianship of the planet, and help to create a better and more peaceful world (IBDP, 2009). Thus, internationalism and covering the international dimension of science are one of the most important aims for IBDP. Both the IBDP curriculum and the selected IBDP biology textbook were therefore also examined in terms of how internationalism is linked to the topics of cellular respiration and photosynthesis. In contrast, the MEB curriculum has little emphasis on internationalism. For instance, there are only three out of thirty-three "Science, Technology, Society and Environment" (STSE) outcomes which give links to internationalism (SSTE 25, 26, 32).

Cellular respiration and photosynthesis in the MEB and IBDP curricula

Whereas cellular respiration and photosynthesis are covered in grade 10 within the unit of energy conversion in living organisms in MEB, in IBDP those topics are

covered in three different topics namely: topic 3: the chemistry of life (after enzymes); topic 8: cell respiration and photosynthesis; option C: cells and energy (after enzymes). Topic 8 is core material for students who take IBDP biology as higher level and option C is an option for students who take IBDP biology as standard level.

Since IBDP is for grades 11 and 12, it depends on the teacher to cover those topics either in grade 11 or grade 12. The IBDP biology subject guide states that teachers may make their own topic arrangements according to their circumstances (IBDP biology subject guide, 2009, p. 40). Moreover, the only difference between the objectives of topic 8 and option C is "analyse data relating to respiration/photosynthesis" (Tables 5 and 6). For this reason, the comparison of MEB and IBDP objectives was done by considering IBDP's topic 3 and option C.

In MEB, 30 hours are devoted for both cellular respiration and photosynthesis at the beginning of grade 10. In IBDP, as a part of spiral structure, 2 hours (topic 3) + 5 hours (topic 8) + 6 hours (option C) = 13 hours are devoted for cellular respiration and 3 hours (topic 3) + 5 hours (topic 8) + 6 hours (option C) = 14 hours are devoted for photosynthesis. An IBDP standard level biology student who chooses option C takes 8 hours cellular respiration and 9 hours photosynthesis, total of 17 hours for both, whereas the total hours for an IBDP higher level biology student is 15 hours, surprisingly 2 hours less. Therefore, the hours devoted for processing these topics are quite different in MEB and IBDP (30/15).

Table 5

Objectives of cellular respiration in the two curricula

MEB objectives for cellular respiration	IB objectives for cellular respiration topic 3	IB objectives for cellular respiration topic 8 + *option C
Explain the importance of respiration for living organisms Draw the diagrams of the glycolysis, Krebs cycle and ETC Do experiments of the molecules that are used and produced during aerobic respiration Show the steps where carbohydrates, lipids and proteins join to the aerobic respiration on diagram Explain that, during anaerobic respiration, ethanol and lactic acid are produced from glucose Compare aerobic and anaerobic respiration	Define *cell respiration*. State that, in cell respiration, glucose in the cytoplasm is broken down by glycolysis into pyruvate, with a small yield of ATP. Explain that, during anaerobic cell respiration, pyruvate can be converted in the cytoplasm into lactate, or ethanol and carbon dioxide, with no further yield of ATP. Explain that, during aerobic cell respiration, pyruvate can be broken down in the mitochondrion into carbon dioxide and water with a large yield of ATP.	State that oxidation involves the loss of electrons from an element, whereas reduction involves a gain of electrons; and that oxidation frequently involves gaining oxygen or losing hydrogen, whereas reduction frequently involves losing oxygen or gaining hydrogen. Outline the process of glycolysis, including phosphorylation, lysis, oxidation and ATP formation. Draw and label a diagram showing the structure of a mitochondrion as seen in electron micrographs. Explain aerobic respiration, including the link reaction, the Krebs cycle, the role of NADH + H+, the electron transport chain and the role of oxygen. Explain oxidative phosphorylation in terms of chemiosmosis. Explain the relationship between the structure of the mitochondrion and its function. *Analyse data relating to respiration

Table 6

Objectives of photosynthesis in the two curricula

MEB objectives for photosynthesis	IB objectives for photosynthesis topic 3	IB objectives for photosynthesis topic 8 + *option C
Explain the structure of chloroplast and its importance for photosynthesis	State that photosynthesis involves the conversion of light energy into chemical energy.	Draw and label a diagram showing the structure of a chloroplast as seen in electron micrographs.
Show oxygen release during photosynthesis by an experiment	State that light from the Sun is composed of a range of wavelengths (colours).	State that photosynthesis consists of light-dependent and light independent reactions.
Compare light dependent and light independent reactions in terms of products and process	State that chlorophyll is the main photosynthetic pigment.	Explain the light-dependent reactions.
Explain factors that affect photosynthesis rate	Outline the differences in absorption of red, blue and green light by chlorophyll.	Explain photophosphorylation in terms of chemiosmosis.
Test effects of at least one factor that affects the photosynthesis rate	State that light energy is used to produce ATP, and to split water molecules (photolysis) to form oxygen and hydrogen.	Explain the light-independent reactions.
Explain how glucose converts into different organic molecules	State that ATP and hydrogen (derived from the photolysis of water) are used to fix carbon dioxide to make organic molecules.	Explain the relationship between the structure of the chloroplast and its function.
Explain how chemosynthesis differs from photosynthesis by giving examples to chemosynthetic organisms	Explain that the rate of photosynthesis can be measured directly by the production of oxygen or the uptake of carbon dioxide, or indirectly by an increase in biomass.	Explain the relationship between the action spectrum and the absorption spectrum of photosynthetic pigments in green plants.
Explain the relationship between photosynthesis and respiration energy converts.	Outline the effects of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis.	Explain the concept of limiting factors in photosynthesis, with reference to light intensity, temperature and concentration of carbon dioxide.
		*Analyse data relating to photosynthesis

All of the objectives of IBDP topic 3 for both cellular respiration and photosynthesis aim to recall the information (Tables 5 and 6). Even if the verb "explain" is used, the intended aim is to recall the information. However, even though a majority of the objectives of the MEB curriculum and the IBDP option C are recall, there are few objectives which require higher order thinking skills. Explain and analyse are the verbs which require higher order thinking skills. MEB has more verbs which refer to higher order thinking skills such as explain, compare and test. Moreover, some MEB

objectives have links to real life which makes it easier for students to understand biology concepts such “explain the importance of respiration for living organisms” (Table 5).

In addition to the general aim and objectives for the unit energy conversion in living organisms, the MEB biology curriculum clearly explains the aim of this unit as to:

> …make students inquire into the importance of energy conversion mechanisms in living organisms, to learn the process of aerobic respiration, anaerobic respiration and photosynthesis, to perform experiments on those topics, to acquire the idea of a circular renewal of ATP, and to gain necessary skills, attitudes and understanding for scientific literacy about key concepts of respiration and photosynthesis. (TTKB, Secondary Education Programs, 2008, p. 30)

The MEB biology textbook perfectly aligns with the grade 10 curriculum. Learning outcomes are covered properly in the textbook. Practical work directly points out the particular outcomes. Real life examples can be seen both in the content and in the questions as it is required by MEB in terms of achieving standards of constructivist approach. Moreover, STSE outcomes are also covered in different parts of the energy conversion in living things topic.

The IBDP biology textbook is aligned with the curriculum. The topics and subtopics comprehend requirements of all of the assessment statements. It is possible to find some boxes which direct students to think about internationalism and Theory of Knowledge (TOK). However, the IBDP biology textbook does not include any practical work, which shows incompatibility with the curriculum. The textbook also has a link to the Heinemann website in which animations and some practicals are available for students.

Level of treatment

In this section the textbooks were analysed in order to understand how well the level of the treatment of content matches the standards of the curriculum, student abilities and grade level, and the time periods allowed for teaching.

In both the MEB and IBDP textbooks the topics, cellular respiration and photosynthesis, are explained in a structure which is from simple to more complex. Each subtopic gives a general overview about the topic and then, by adding more and more detail, the topic is explained in a more specific way. For example: in the MEB textbook the general overview of aerobic respiration is given as: "ATP is produced by chemical bond energy of organic molecules in cells. If oxygen is used while synthesizing ATP by breaking down organic molecules it is called aerobic respiration." (Akkaya *et al.*, 2011, p. 23). After that definition, the places where aerobic respiration occurs and the steps of aerobic respiration are explained in detail.

In the MEB textbook almost all of the subtopics of cellular respiration and photosynthesis start with some real life examples and thinking questions related to that example and topic. In the IBDP textbook, real life examples are used rarely throughout the text.

Cellular respiration and photosynthesis are topics considered difficult by students. Some important components are considered to be essential parts of teaching and learning the two topics. Textbooks should give appropriate background information, details and real life connections in order to make them more understandable. Tables 7 and 8 show subtopics that need to be covered while teaching cellular respiration and photosynthesis in order to increase students' understanding and give more

appropriate background information, with comparison of their coverage in both books.

Table 7

A comparison of subtopics of cellular respiration covered in the two textbooks

Cellular respiration	MEB	IB chapter 3	Chapter 8	Option C
ATP	✓	✗	✗	✗
Catabolic-anabolic pathways	✓	✓	✓	✓
Oxidation-reduction reactions	✗	✗	✓	✓
The ATP-ADP cycle	✓	✗	✗	✗
Aerobic cellular respiration	✓	✓	✓	✓
Electron transport chain and chemiosmosis	✓	✗	✓	✓
Anaerobic cellular respiration	✓	✓	✗	✗
Starting points of synthesis of other metabolites	✓	✗	✗	✗
Total	**7**	**3**	**4**	**4**

Table 7 shows that both textbooks lack some important information about cellular respiration. Whereas MEB does not include any information about oxidation and reduction reactions, IBDP does not cover ATP and the ATP-ADP cycle. ATP and the ATP-ADP cycle are essential components that must be given clearly before the processes of cellular respiration and photosynthesis are covered. Students need to understand ATP is universal energy currency for living organisms (NRC, 1996). In the MEB textbook the unit Energy Conversion starts with ATP and the textbook devotes 3 pages to explain what ATP is and why it is important for living organisms. Life connections which make students think about the role of energy and correlate ATP with their daily life are given in the ATP subtopic.

However, in the IBDP textbook, ATP is not explained. There is no explanation for ATP either in the related topics or in other topics. ATP is only mentioned briefly: "energy is released in the form of ATP" (Damon *et al.,* 2008, p. 70). This gap makes

the level of treatment inappropriate for students, because without understanding ATP well, there is no way to understand the logic behind cell respiration and photosynthesis.

Table 8

A comparison of subtopics of photosynthesis covered in the two textbooks

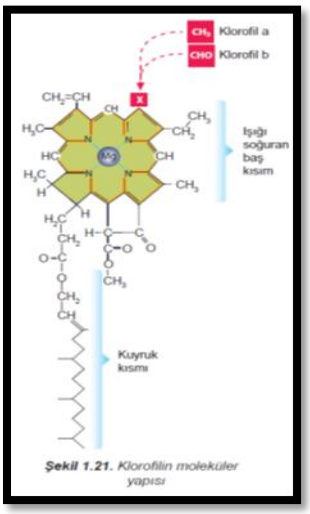
Photosynthesis		MEB	Topic 3	Topic 8	Topic C
General overview of photosynthesis		✓	✓	✗	✗
Light/ what is light?		✓	✗	✓	✓
Absorption spectrum		✓	✗	✓	✓
Chloroplast		✓	✗	✓	✓
Chlorophyll and other pigments		✓	✗	✓	✓
The light dependent reactions		✓	✓	✓	✓
Photophosphorylation		✓	✗	✗	✗
The light independent reactions		✓	✓	✓	✓
Measuring the rate of photosynthesis		✓	✗	✓	✓
Factors affects rate of photosynthesis	Light intensity	✓	✓	✓	✓
	Temperature	✓	✓	✓	✓
	CO2	✓	✓	✓	✓
	Water	✓	✗	✗	✗
	Minerals	✓	✗	✗	✗
	pH	✓	✗	✗	✗
	Genetic factors	✓	✗	✗	✗
Cyclic photophosphorylation		✓	✗	✓	✓
Chemosynthesis		✓	✗	✗	✗
Total		**18**	**6**	**11**	**10**

Cellular respiration and photosynthesis are complex redox reactions. Therefore, oxidation and reduction reactions must be explained in order to increase students' learning. Whereas IBDP explains oxidation and reduction reactions at the beginning of topic 8 and option C, MEB does not mention it (Table 7). The problem about MEB is that the terms oxidation and reduction are used several times in the topic, but

there is no explanation about them. Endergonic and exergonic reactions are explained in the MEB textbook but there is no explanation in the IBDP textbook.

As seen in Table 8 the MEB textbook covers all of the subtopics about photosynthesis, however some of these topics may cause overload of knowledge especially for students in grade 10. In the MEB textbook there are encyclopaedic details which are very complex and difficult for this grade level. For example: the molecular structure of chlorophyll pigments is covered which can be distracting and complicated for grade 10 students (Figure 1a). Moreover, factors affecting the rate of photosynthesis are covered in great detail, and graphs are complicated because the effects of two limiting factors are explained in the same graph (Figure 1b). Chemosynthesis is explained by using many names of bacteria such as *Nitrosomas, Beggiatoa, Thiospirillum* (Akkaya *et al.*, 2011, p. 86).

(a)



(b)

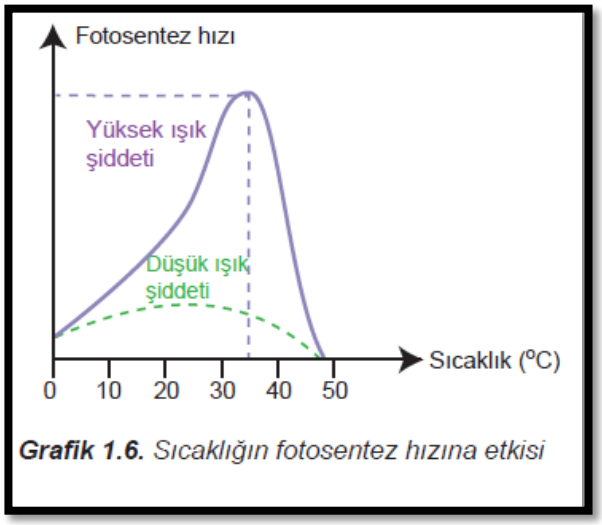


Figure 1 (a). Structure of chlorophyll pigment is given in detail in the MEB grade 10 biology textbook (b). A complex illustration from the MEB textbook which shows two limiting factors in the same graph

As a conclusion, in both textbooks some important content is missed or is not introduced appropriately. In the MEB textbook, some detailed knowledge, excessive

use of scientific terms, complex and unclear drawings make the content difficult to understand for the grade level.

Accuracy of content

The content of both textbook is mainly accurate, but some misleading statements and misconceptions were detected. They are presented in Table 9 with a more accurate definition.

Table 9
Examples of misleading statements with recommended definition

Misleading statements in the IBDP textbook	Recommended definition
Each covalent bond in a *glucose*, amino acid or fatty acid represents stored chemical energy (p. 70).	Each covalent bond in a *monosaccharide*, amino acid or fatty acid represents stored chemical energy.
In this case, pyruvate is converted to lactate in animals, and ethanol and carbon dioxide in *plants* (p. 220).	In this case, pyruvate is converted to lactate in animals, and ethanol and carbon dioxide in *yeast* (single-celled fungus).
Ethanol is a 2-carbon molecule, so a carbon is *'lost'* in this conversion (p. 71).	The word "lost" leads misconceptions so that, nothing has been lost in living organisms.
Each pyruvate first *loses* a carbon dioxide molecule and becomes a molecule known as acetyl-CoA (p.73).	Each pyruvate *gives off* a molecule of carbon dioxide and coenzyme A is attached to acetyl to form acetyl-CoA (Campbell *et al*, 2008)
Misleading statements in the MEB textbook	Recommended Definition
All living things in the ecosystem such as animals, plants and even *one cell* need energy to survive (p. 17).	All living things in the ecosystem such as animals, plants and even *one cell organism*s need energy to survive.
Glucose is broken down into *3-carbon molecule* by variety of enzymes (p. 25).	Glucose is broken down into *pyruvate, 3-carbon molecule*, by variety of enzymes.
The last stage of cellular respiration is given as "Electron Transport Chain" (p. 31).	It should be corrected as *"Electron Transport Chain and Chemiosmosis"* because ETC makes no ATP, chemiosmosis produces ATP.

In addition to the texts, some inconsistencies are also found in the visuals of the two textbooks. Figure 2 presents a summary of ATP production in different parts of a cell in the MEB textbook. However, the number of produced ATPs in substrate level phosphorylation and oxidative phosphorylation is not correct and is not compatible with what is written in the text.

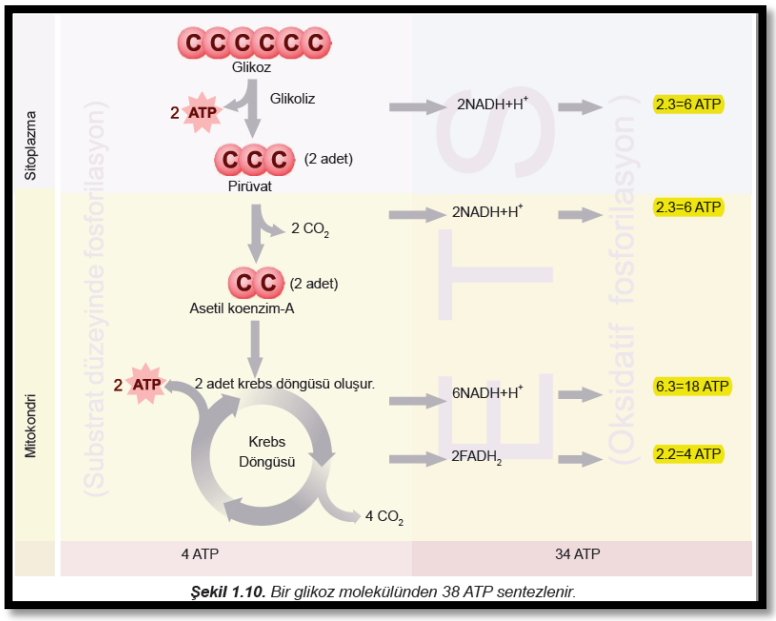


Figure 2. An illustration from the MEB textbook contains errors in the number of ATP that are produced in cytoplasm and mitochondria.

An inconsistency between the text and the visual is also found in the IBDP textbook; the graph which shows correlation between rate of photosynthesis and wavelengths is explained with an error (Figure 3). Whereas the graph shows that the violet and red lights show the greatest absorption, the text says blue and red lights show the greatest absorption (Damon *et al*., 2007, p. 407).

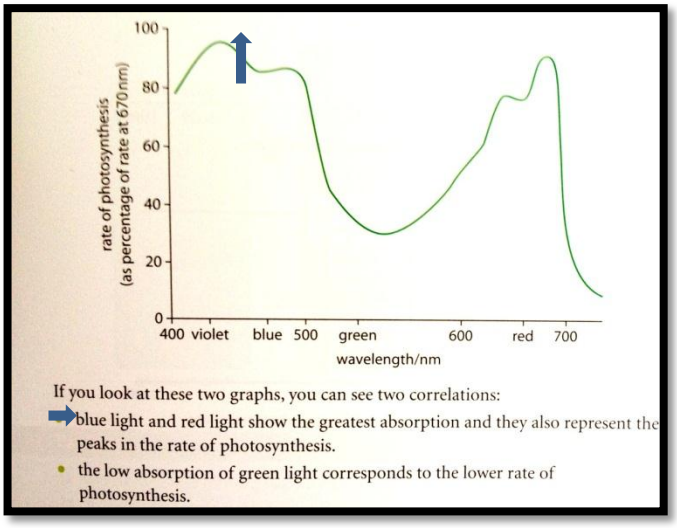


Figure 3. Inconsistency between the visual and the text from the IBDP textbook (Damon *et al*., 2007)

In the IBDP textbook, photomicrographs are presented in a more scientific way compared to the MEB textbook. While in the IBDP textbook, for all photomicrographs, the microscope type (SEM, TEM, and light microscope), colour type and magnification are written, in the MEB textbook this information is not included. Moreover, in the MEB textbook for some photographs of bacteria, the bacteria are not named (Figures 4a, 4b, 4c). Lack of that vital information makes the content inaccurate and inadequate.

(a)

(b)

(c)

Figure 4. Example photomicrographs from the two textbooks (a) photomicrograph of anaerobic bacteria from the IBDP textbook (Damon *et al.*, 2007); (b) photomicrograph of bacteria from the MEB textbook; (c) photomicrograph of cyanobacteria from the MEB textbook (Akkaya *et al.*, 2011)

Authenticity of content

Authenticity of content was evaluated under two categories: real life connections and interdisciplinary treatments.

Real life connections

Real life connections from the two textbooks are shown in Table 10. As Table 10 shows, the MEB textbook includes more daily life examples and connections compared with the IBDP textbook. The number of life connections in the MEB textbook is nearly four times more than that of the IBDP textbook. In the MEB textbook, most of the examples are given at the beginning of subtopics. In the IBDP

textbook, the presentation of daily life connections does not have a specific place during the text. One may find a real life connection in an information box, or after a long explanation or any other place.

Table 10

Real life connections from the two textbooks

	MEB
Cellular respiration	1. Toast, sandwich and different types of bread are made from wheat, a herbaceous plant. (p.17) 2. How does wheat that is consumed by people all over the world fulfil daily nutrition needs? (p.17) 3. Athletes eat carbohydrate-rich food while getting ready for heavy exercise in order to load their cells with carbohydrates (p 19). 4. Have you ever thought how much energy you use when you make research on internet or study or which of your cells require more energy when you read a book or play sport? (p 21) 5. Is the same amount of energy being produced in the muscle cells of an old person and a child? (p 21) 6. Effects of slow metabolism on a person even if there is no change in the diet. (p. 22) 7. When we burn a sugar cube, energy is released as heat. (p. 22) 8. Athletes prefer oxygen-rich places in order to increase efficacy of their exercise. Why do athletes practice regularly and why do they prefer oxygen-rich places? (p. 23) 9. To do regular exercise what kind of changes are made in muscle cells? How do those changes affect oxygen-using capacity? (p. 23) 10. How can milk become yoghurt and grapes become vinegar? (38) 11. Your muscle cells produce much energy rapidly while exercising or running. (38) 12. *Beer and champagne can bubble by CO2 which is released during ethyl alcohol fermentation*. (40) 13. *CO2 helps dough to rise. (*40) 14. The reason why humans get tired during swimming is the accumulation of the lactic acid in their leg's muscle cells. (42) 15. If the amount of lactic acid that accumulates in blood increase, it goes to the brain via the blood and stimulates sleep centre. This is why we feel sleepy when we get tired.
Photosynthesis	1. When we drink tea we drink sun's energy indeed. (60) 2. Why do we see objects in different colours? (63) 3. Why are herbaceous plants, leaves and branches of a tree and raw fruits green? (63) 4. Why do leaves change colour in autumn? (63) 5. Do house plants photosynthesize in artificial light? 6. How are fruits presented by nature synthesized? (76)
	IBDP
Cellular respiration	1. *All alcohol for drinking is ethanol. Beer, wine and spirits contain different proportions of ethanol and other ingredients for flavouring*. (p. 71)-information box. 2. Bakers' yeast is added to bread products for baking as the generation of carbon dioxide helps dough to rise. It is also common to use yeast in the production of ethanol as drinking alcohol. (p. 71) 3. A person pushing beyond their normal exercise pattern or routine cannot supply enough oxygen to their cells. (p. 71) 4. Energy is topic of everyday in our modern world. We talk about the energy needed for transport. We talk about being so tired after a long day at school that we need a short nap. The need for food becomes essential at times to regain the energy level necessary for us to function (p. 217)
Photosynthesis	1. The vast majority of plant leaves appear green to our eyes (74) 2. Water droplets are natural prisms, which is why different colours of sunlight can be seen in a rainbow (74). 3. The advice to wear light coloured clothing in warm months is good advice based on the principle that lighter colours reflect more energy and therefore keep you cooler. (p. 75)

As seen in Table 10, both textbooks used more daily life connections in cellular respiration than in photosynthesis. Especially in the MEB textbook there is a huge difference between the two topics in the number of daily life connections (15/6). The two textbooks use similar real life connections in cellular respiration such as "CO2 helps dough to rise". However, real life connections used for photosynthesis are different in the two textbooks.

Interdisciplinary treatments

Both textbooks have links to chemistry, physics, history and mathematics. The frequency and depth of those links are different in the two textbooks. For example: oxidation and reduction reactions are explained in detail only in the IBDP textbook (Damon *et al.,* 2007, p. 217) and information about radioactive isotopes is given only in the MEB textbook (Akkaya *et al.,* 2011, p. 24). In the photosynthesis topics, links to physics (light, wavelengths, photons and electromagnetic spectrum) are explained in both the IBDP and the MEB textbook. The MEB textbook also has links to mathematics, because questions which require calculations of the number of products, reactants and coenzymes of cellular respiration and photosynthesis are given as exercises.

The MEB textbook also gives a historical development of the discoveries which have led to our present understanding of photosynthesis (Akkaya *et al*., 2011, p. 52), and the life of important researchers who contributed to our knowledge of cellular respiration and photosynthesis such as Hans Krebs, Eugene Kennedy, Albert Lehninger, Peter Michell and Melvin Calvin (Akkaya *et al*., 2011, p. 27, 31, 32). In the IBDP textbook, the only link to history is brief information on Calvin's

experiment from 1955 which is in the TOK box. There is also a link to art in the IBDP textbook in a TOK box (Damon *et al.*, 2007, p. 404).

Presentation

The presentation style of the textbooks was evaluated in terms of organization, readability, pacing, and ease of use.

Organization of the two textbooks

Number of pages devoted for each topic is displayed in Table 11. The MEB textbook contains nearly twice as many pages than the IBDP textbook for each topic.

Table 11
Number of pages devoted for each topic

	MEB	IBDP		
		Topic 3	Topic 8	Option C
Cellular Respiration	32	5	10	10
Photosynthesis	37	5	10	10

Students' understanding can be increased by logical organization. For example, it is not easy to understand cellular respiration and photosynthesis without first knowing what ATP is. Besides, the correct orders of reactions are essential for understanding energy conversion in living organisms. Tables 12 and 13 show the order in which the subtopics of cellular respiration and photosynthesis were given for each textbook.

Table 12

Order of subtopics of cellular respiration in the two textbooks

MEB	IBDP
Respiration in living organisms: Release of energy	Cell respiration
A. Basic molecule of energy ATP	Assessment statements
B. Energy requirements of living organisms	Oxidation and reduction
C. Aerobic respiration	An overview of respiration
1. Glycolysis	Glycolysis
2. Krebs cycle reactions	Summary of glycolysis
3. Electron transport chain	Mitochondria
D. Pathways of foods	The link reaction and Krebs cycle
E. Anaerobic respiration	Electron transport chain and chemiosmosis
1. Ethyl alcohol fermentation	Summary of ATP production in cellular respiration
2. Lactic acid fermentation	Final look at respiration and the mitochondrion
Topic-end assessment	Exercises
	Practice questions

Table 13

Order of subtopics of photosynthesis in the two textbooks

MEB	IBDP
Photosynthesis	Photosynthesis
A. Producers of biosphere	Assessment statements
B. Structures that photosynthesis occurs in	The chloroplast
1. Structure of chloroplast	Overall process of photosynthesis
2. Sun light (electromagnetic spectrum)	The light-dependent reaction
3. Pigments of photosynthesis	The light-independent reaction
4. Excitement of chlorophyll by light	The chloroplast and photosynthesis
C. Photosynthesis reactions	Action and absorption spectra of photosynthesis
1. Light-dependent reactions	Factors affecting photosynthesis
a. non-cyclic photophosphorylation	Cyclic photophosphorylation
b. cyclic photophosphorylation	Exercises
2. Light-independent reactions	Practice questions
D. Synthesis of organic molecules	
E. Factors affecting photosynthesis rate	
1. Environmental factors	
2. Genetic factors	
C_3, C_4 and Cam plants (optional)	
Topic-end assessment	
Measurement and evaluation	

The order of reactions which occur in photosynthesis and cellular respiration are mostly given in the correct order in the two textbooks. The orders of subtopics are from general to specific in the two textbooks. However, in the MEB textbook mitochondrion is explained before glycolysis, whereas in the IBDP textbook it is explained after glycolysis.

In the first pages of the MEB textbook, there is a section titled, "Let's know our book". It gives information about the general structure of the textbook and instructions about how to use it. Information boxes, activities and assessment are clearly explained (Figure 6a). Sample pages from the book are used in order to give information about its structure. In the next page, there are lab safety symbols and their explanation. After that, the table of contents starts with a picture relating to each unit. The table of contents is given in great detail. It shows all of subtopics and their page numbers. At the end of each topic there is a unit assessment and a one page essay. The MEB biology textbook also includes index, glossary and bibliography. Each unit has different colour code.

The IBDP textbook gives the table of contents before the introduction. Similar to the MEB textbook, content, information boxes and assessments are explained. Since the IBDP textbook does not include any practical work, there is no information about lab safety symbols (but note that it is possible to see lab safety symbols in the Heinemann website). Each topic has a different colour code, and starts with assessment statements box which includes numbered IB objectives for the related topic. Surprisingly, the IBDP textbook does not include a glossary or a bibliography, but it has an index at the end of the book (Table 14).

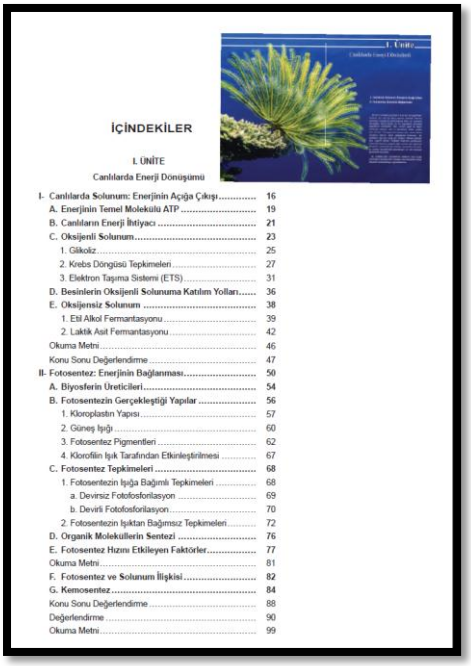
Table 14

Organization of the two textbooks

	MEB	IBDP
Table of contents	✓	✓
Directions on how to locate information	✓	✓
Introduction for each topic	✓	✗
Labelled reviews or summaries	✗	✓
Index	✓	✓
Glossary	✓	✗
Bibliography	✓	✗
Total	**6**	**4**

Headings and subheadings are very clear in the table of contents in the MEB textbook; however the IBDP textbook gives only topic names in the table of contents which makes it difficult to use for students (Figures 5a and 5b).

(a)


İÇİNDEKİLER

I. ÜNİTE

Canlılarda Enerji Dönüşümü

(b)

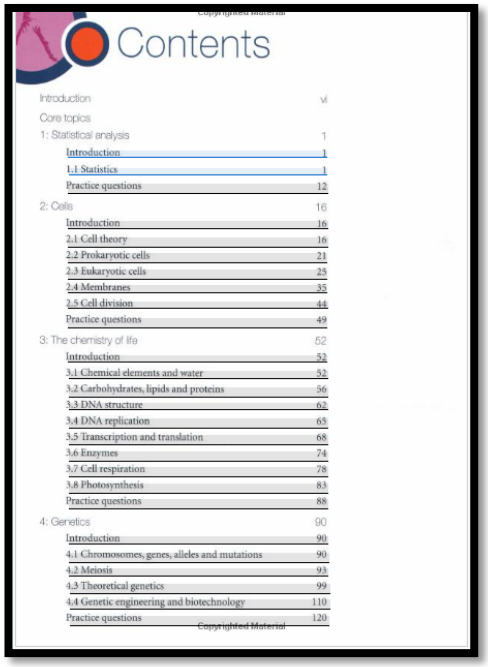
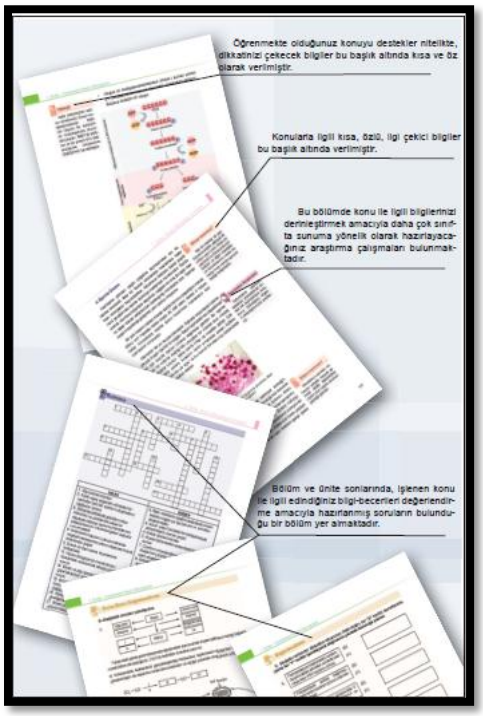

Contents

Figure 5. Table of contents of the two textbooks (a) the MEB textbook (b) the IBDP textbook

In the MEB textbook, there are three different information boxes. They are: Attention!, Do you know? And Let's Think- Let's Search (Figure 6a). There are six types of information boxes in the IBDP textbook each of which refers different information (Figure 6b). They are: Theory of knowledge, interesting information, key facts, global perspective, examiner's hint, Heinemann website.

(a)



(b)

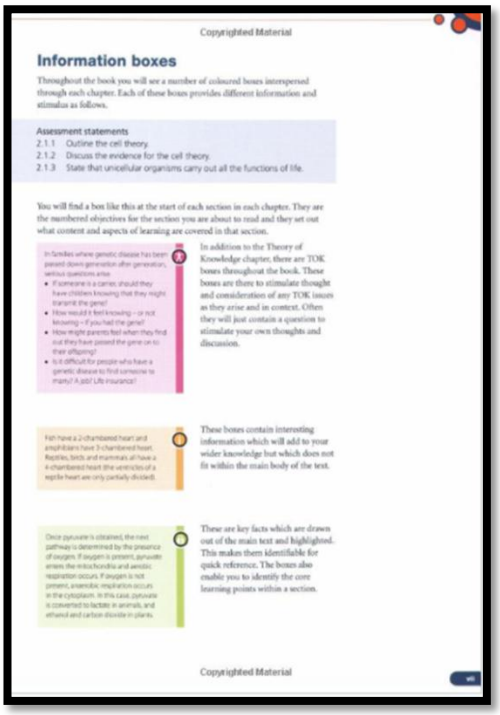


Figure 6. Sample pages from the two textbooks (a) the MEB textbook (b) the IBDP textbook

Although in the MEB textbook, topics are summarized at the end of subtopics, summaries are not labelled and they are given as a paragraph. In the IBDP textbook, there are labelled summaries for glycolysis (Damon *et al.,* 2007, p. 398) and ATP production in cellular respiration (Damon *et al*., 2007, p. 393) which are written as bullet points, but in photosynthesis instead of labelled summaries comparison tables are used which also have connection to cellular respiration. For example: comparison of chemiosmosis in respiration and photosynthesis (Damon *et al*., 2007, p. 403).

In the MEB textbook, “the energy conversion in living organisms” unit starts with a short essay about respiration and nourishment of crinoids, animals that live in coral reefs. The life cycle of crinoids is gently linked to the following statement, “In order to survive they need energy like other living things, this energy can be supplied by a number of chemical reactions which occur in their cells” (Akkaya *et. al*., 2011, p. 15). This is a good way of starting the topic, an intriguing link to the life of animals. The textbook also says, “in this unit, you will learn how energy is released from cells and how compounds that are raw materials of energy are synthesized” (Akkaya *et. al*., 2011, p. 15). Therefore, this is good introduction for the topic of energy and increases the curiosity of students.

Different from the MEB textbook, the IBDP textbook, in topic 3, does not begin by giving any interesting example. Instead, it enters the topic directly by saying, “organic molecules contain energy in their molecular structure” (Damon *et. al*., 2007, p. 70). However, in topic 8 and option C (which are repeated versions of each other), the topic begins with the energy needed in daily life such as transportation and how the body requires food in order to regain energy. Similar to the MEB, the IBDP textbook says, “this chapter looks at energy in living systems”, but in the next sentence, it restricts the living systems to animals and plants only.

In the MEB textbook, the introduction is followed by KWL chart activity. The activity aims to show what students know about the topic, what they want to learn and what they will have learned at the end of the unit. Therefore students are required to fill in the KWL chart at the beginning and at the end of the topic.

In the MEB textbook at the end of each topic, there is end-of-topic assessment; at the end of the unit there is a measurement and evaluation section. Similarly in the IBDP

textbook there is a section with exercises consisting of four or five questions per topic, and practice questions after each chapter.

Readability

Readability includes language style, typographical presentation features, and visual features.

The readability scores of the two textbooks were very close to each other with 48.6 for the MEB textbook and 48.1 for the IBDP textbook. The Flesch Reading Ease scale ranges from zero to 100. Zero to 40 is very difficult to read. Eighty and above is easy to very easy. These scores of 48.6 and 48.1 are clarified as difficult readability level according to the Flesch readability score classification (Appendix A). They are equated with grade level 10. Stockmeyer (2009) notes that even college level graduates prefer to read general materials written at the 10^{th} grade level and grade level 12 is too difficult for many readers.

Grammar mistakes are also some additional problems in the MEB textbook which make readability even more difficult for students.

Typographical features that affect the readability of textbooks were also analysed and are summarized in Table 15.

Table 15

Comparison of typography of the two textbooks

MEB	IBDP
The binding and cover is strong.	The binding and cover is strong.
Printing is done off-white, uncoated matt paper.	Printing is done off-white, uncoated glossy paper.
Its format is A4.	Its format is A4.
Its layout is single-column, portrait type	Its layout is single-column, portrait type
The font is Times New Roman with 12.5 font size.	The font is Arial with 9 font size.
An orderly system of access devices is inserted in the text.	An orderly system of access devices is inserted in the text.
The text is grouped in units of meaning.	The text is grouped in units of meaning.
The illustrations are mostly coloured drawings.	The illustrations are mostly coloured drawings.
The illustrations are placed close to the text referring to it.	The illustrations are placed close to the text referring to it.

In the MEB textbook each level of subheading has a different colour. The A level subheadings are in red, the B level subheadings are in dark purple with lower font size and the C level subheadings are in black. Each level of subheading has easy to follow numbers. The IBDP textbook has the same colour for all headings and subheadings, but different font sizes with no reference numbers.

In both textbooks, the text is laid from the centre to the edge (Figure 7). There is a margin on the left or right side of the paper, which can be used for notes. Information boxes are presented in those blank areas.

(a) 

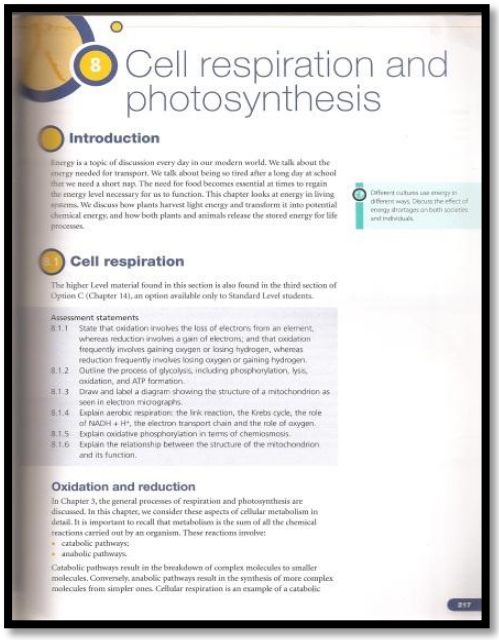
(b) 

Figure 7. Sample pages from the two textbooks (a) the MEB textbook; (b) the IBDP textbook

Whereas in the IBDP textbook, new scientific terms are not indicated in bold style, in the MEB textbook all new scientific terms are written in bold. They can be more quickly read when emphasis is required (Johnson, 1998). There is a consistency in the colours of units, practical work, tables, information boxes and questions boxes in both MEB and IBDP textbook.

Visuals in the textbooks were counted and classified as photographs, drawings, photomicrographs, tables, graphs and computer graphics (Table 16).

Table 16

Number and types of visuals that are used in the two textbooks

Types of visual	MEB		IBDP	
	Cellular respiration	Photosynthesis	Cellular respiration	Photosynthesis
Drawings	14	16	14	8
Photographs	5	16	-	1
Photomicrographs	2	4	3	3
Graphs	-	8	-	9
Tables	4	3	3	3
Computer graphics	-	-	1	-
Total	25	47	21	24

The MEB textbook has the highest number of visuals with 72 visuals. 45 visuals are counted for the IBDP textbook. Most of the drawings in the IBDP and MEB textbooks have high resolution, but some problems are detected in some visuals in the MEB textbook. For example; the drawing that illustrates a cross section of a leaf and the structure of the chloroplast has bad resolution which can affect students' understanding (Figure 8).

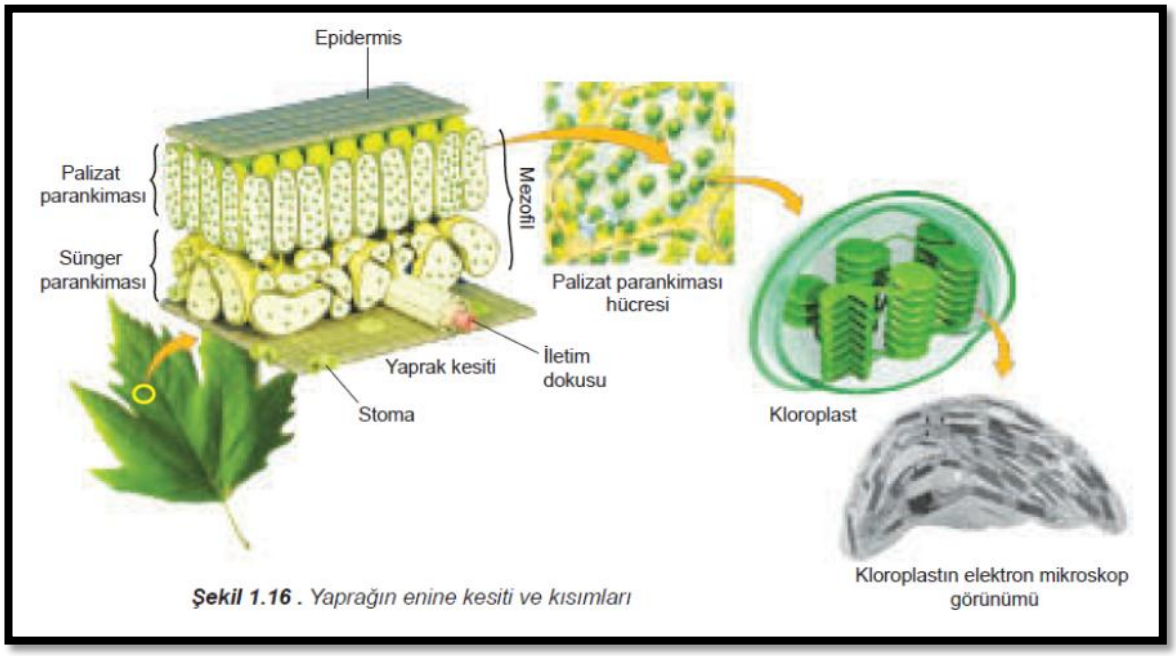


Figure 8. An example of bad resolution in visuals in the MEB Biology textbook (Akkaya *et al*., 2011, p. 57)

Ease of use

In the IBDP textbook, print quality is high with colourful illustrations in A4 format. The textbook gives free access to the Heinemann website in which the reader can find animations, chapter reviews and computer simulations. There is an entry code for students and by using that code students can reach the website without any assistance. However, practicality of the IBDP textbook is controversial because it contains both HL and SL topics in one book. This makes the book very heavy with 706 pages, so that using the book in a classroom environment or at home is difficult, as is carrying it back and forth. Heavy weight and too many pages make the book difficult to use and find related materials. Moreover, after using and reading it several times, the book splits which is bad for the durability of the textbook. Also, this book is one of the most expensive IBDP textbooks (115 TL), affordability of textbook can cause problems for students, even though the book is for a 2- year program.

The MEB textbook is only for one-year use and it contains three units. Similar to the IBDP textbook, the MEB textbook is in A4 format with full colour illustrations. It contains 264 pages and is easy to carry and use. When comparing with the IBDP textbook, the MEB textbook is more practical to use in the classroom and at home. It allows students to find easily what they look for, and read and take notes near the text. However, different from the IBDP textbook the MEB textbook has no link to any website nor does it contain any CD-ROMs, electronic media or computer-based activity. The price of the MEB textbook is very low (6 TL) and in state schools textbooks are given by the Ministry without any cost to the students.

Learning strategies

All three criteria that were used in this study are very important and need to be considered together. Accurate content with appropriate level of treatment serves students' learning. The presentation style of the textbook has contribution on students' learning as well. Thus, the main goal of the textbook or any other instructional material is to increase students' learning. This section now moves to consider learning strategies.

The two textbooks were examined for learning strategies by considering motivational strategies, teaching a few big ideas, explicit instruction, guidance and support, active participation of students and targeted assessment strategies.

Motivational strategies

The two textbooks have similarities and differences in terms of motivational strategies. The IBDP textbook sometimes has a monotonous and mechanical wording style and sometimes the language of the textbook becomes less technical. Especially in Chapter 3 and in cellular respiration the language of the IBDP textbook is technical and does not give chance to digest the knowledge given. However, in topic 8.2, in photosynthesis the language is less monotonous than that in cellular respiration, which suggests inconsistency in the language of the IBDP textbook. Real life connections and students' involvement are very few. There are four questions in the text which mean formative assessment is not really considered. Since there are no practicals or any other activities in the textbook, we cannot talk about task design.

Unlike the IBDP textbook, the language of the MEB textbook is not monotonous. When you read it, it seems that someone speaks directly to you. In most of the text,

the subject “we” is used when giving directions. For example: “Let’s examine how two photosystems work together in the production of the two main products ATP and NADP in the non-cyclic photophosphorylation” (Akkaya *et al*., 2011, p. 68).

In the MEB textbook, almost each subtopic starts with daily life examples and many critical thinking questions. For example: “Toast, sandwich and different types of breads are made from wheat, a herbaceous plant. How does wheat that is consumed by people all over the world fulfil our daily nutritional needs?” (Akkaya *et al*., 2011, p.17).

The life of famous researchers and their achievements can be a good way to motivate students and understand the importance of science. In the MEB textbook, the life of Hans Krebs is told, and his achievement on resolving the Krebs cycle reactions which brought him a Nobel Prize is mentioned (Akkaya *et al*., 2011, p. 27).

In addition to daily life examples and critical thinking questions, the MEB textbook also presents many practical activities such as experiments, hands-on activities and filling in charts which require group work, observation and comparison. Since the textbook presents different kinds of activities instead of monotype exercises, it increases students’ motivation. For example, KWL charts are used at the beginning of each topic. KWL charts are a popular tool in differentiated instructions. They help both students and teacher to see the students’ background and expectations with regard to particular topic. KWL chart is explained very well and it directs students to check their answers by the guidance of their teacher. At the end of the unit, the MEB textbook reminds students to fill in the last part of the KWL chart and discuss their answers with their friends. Therefore it encourages collaboration.

In the IBDP textbook, there are examiner hints boxes. They may be useful to show students the important parts of the topic but may also cause over-emphasis on exams for students, thus make the content and textbook exam-oriented.

Student collaboration assignments, group projects, students' communication and presentations are some other factors that can contribute to the students' learning. As stated before, the MEB textbook includes research boxes throughout the unit which directs students' to do research, presentations and practical work such as experiments and make a chloroplast model which increase motivation of students. Moreover, instructions of experiments lead students to work in groups.

The Heinemann website is another source for the IBDP textbook, having an attractive design. Animations are high quality and there are language options for both in Turkish and in English.

Teaching a few big ideas

Table 17 lists the core concepts related to cellular respiration and photosynthesis as stated in the high school science content expectations document produced by Michigan University Department of Education. It also states whether or not they are included in the two textbooks. Whereas the IBDP textbook includes all of the core concepts, the MEB textbook misses some important ones, such as specialization of cells according to their function and endosymbiosis theory.

Table 17

Big ideas which are related to cellular respiration and photosynthesis

Core concepts or big ideas	MEB	IBDP
• Organisms are made up of different arrangements of these molecules, giving all life a biochemical framework.	✓	✓
• Selected cells in multicellular organisms are specialized to carry out particular life functions.	✗	✓
• Carbohydrates and lipids contain many carbon-hydrogen bonds that also store energy. However, that energy must be transferred to ATP (adenosine triphosphate) to be usable by the cell.	✓	✓
• Organisms need energy to do cell work.	✓	✓
• Photosynthesis converts the sun's energy into the chemical potential energy of food.	✓	✓
• Cell respiration converts the chemical potential energy stored in food to the chemical potential energy stored in ATP.	✓	✓
• ATP supplies the energy to do cell work.	✓	✓
• Explain that some structures in the modern eukaryotic cell developed from early prokaryotes, such as mitochondria, and in plants, chloroplasts.		✓
• In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of cells for food, air, and waste removal. The way in which cells function is similar in all living organisms.	✗	✓
• Energy transformations from the sun to organisms provide energy for all life forms to exist.	✓	✓
Total	8	10

(Michigan University Department of Education, 2007)

Explicit instruction

In both the MEB and IBDP textbooks, explicit instructions are clear. In the MEB textbook there are similar activities per chapter such as story about the topic at the beginning and KWL charts after general overview of topics. As stated in the presentation style, the book gives clear instructions about how students should use the textbook, what information boxes stand for, what lab safety rules icons stand for. In general, the overview of cellular respiration and photosynthesis textbook states what students will learn in this topic.

Transitions are clearly given in both textbooks and it is stated clearly where subtopics are ending and the next subtopic starts. For example: in the IBDP textbook, at the beginning of each topic, assessment statements are given as written in the IBDP biology curriculum. Topic 8 starts with an introduction which gives clear instructions about the cellular respiration and photosynthesis topics. It presents a transition between Topic 3 and Topic 8 and it is stated that this chapter covers the topic in detail. Examiner hints boxes are laid throughout all topics, giving tips for possible IBDP exam questions.

Guidance and support

For differentialization, and to fit the differing needs and knowledge of students, different kinds of activities and questions are essential for triggering students' learning. The MEB textbook presents different kinds of activities such as, experiments, group studies, making research, writing reports and making presentations.

Analogies increase learning in science. The analogies of the two textbooks were counted and represented in Table 18.

Table 18

Analogies found in the two textbooks

MEB	IBDP
1. ATP's function as a messenger between endergonic and exergonic reactions. (p. 21) 2. Factory analogy for cell structure and function. (p. 25) 3. ATP synthase constructs a way/road for reflowing of protons to matrix. (p. 32) 4. Chloroplasts are considered as the kitchen of the plant. (p. 57). 5. Granum seems like coins (p. 58). 6. Atmosphere is like selective window for harmful lights. (p. 61)	1. Some people refer to the chloroplast as a photosynthetic machine. (p. 227) 2. Photosynthetic factory (p. 228) 3. Light energy behaves as if it exists in discrete packets called photons (p. 401).

In the IBDP textbook, there is an example of coding in topic 8 which gives hints about how to remember oxidation and reduction reactions in terms of losing and gaining electrons:

> OIL: Oxidation is Loss (of electrons)
> RIG: Reduction is Gain (of electrons). (Damon *et al.*, 2007, p. 391)

In the IBDP textbook, "examiner's hint" boxes are seen throughout the topic 3, topic 8 and option C, either near the relevant text. These boxes provide insight on how to answer a question in order to achieve high marks in an examination. They also identify common pitfalls when answering such questions and suggest approaches that examiners like to see. For example: in topic 8 and option C, there is an examiner's hint box next to the table which compares oxidation and reduction that says, "If you are asked in an exam to compare oxidation and reduction, a table such as this is an excellent way to structure the answer" (Damon *et al.*, 2007, p. 218).

The MEB textbook does not have any technological components such CD and electronic media, whereas the IBDP textbook has a link to the Heinemann website. Students are directed to visit the website throughout the text. In topic 3, there is one web link for each cellular respiration and one web link for photosynthesis.

To support success in learning in science, new scientific terms must be presented clearly. Whereas terms defined immediately promote easier reading and comprehension undefined or later-defined terms discourage students' understanding and make the text more difficult to read (Soyibo, 1996). All the new biological terms found in the topics, cellular respiration and photosynthesis, in both textbooks were counted and analysed as to whether they are defined or not. Defined terms were also categorized as to where they are defined (Table 19).

Table 19

Status of terms in the two textbooks

Categories	**MEB**	**IBDP**
Terms immediately-defined	30	9
Terms earlier-defined	11	6
Terms later-defined	26	31
Terms undefined	23	17
Total	90	60

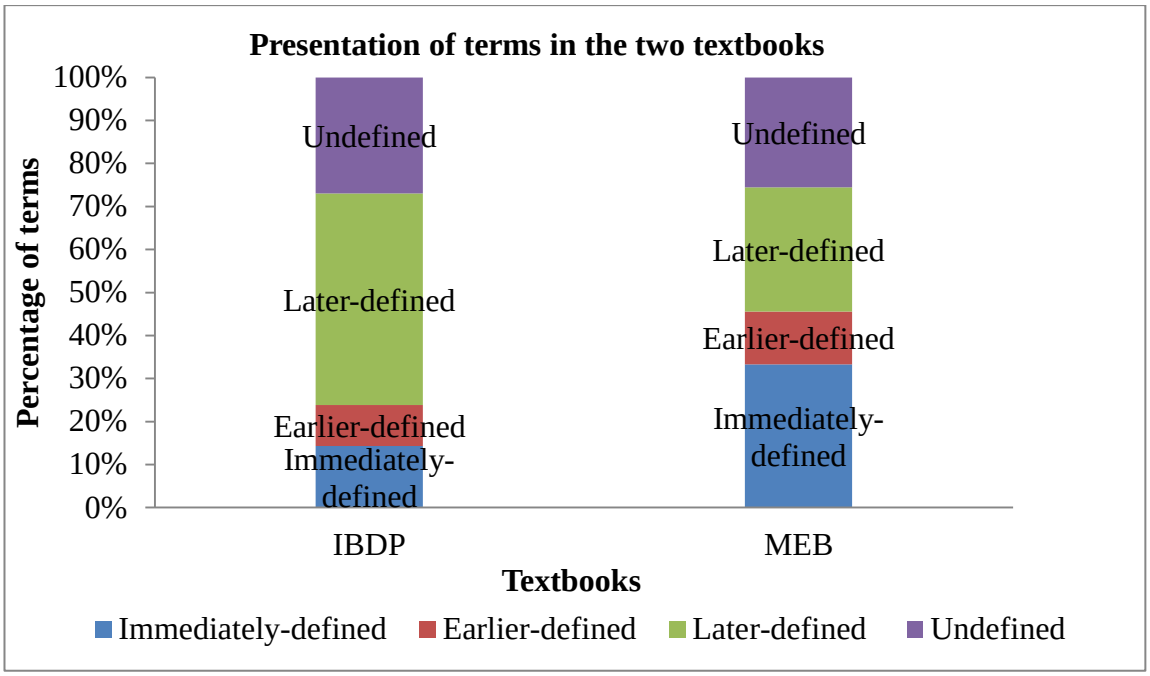


Figure 9. Presentation of terms in the two textbooks

Later-defined or undefined terms block students' learning. The percentage of undefined and earlier-defined terms is similar in the two textbooks (Figure 9). However, the percentage of later-defined and immediately-defined terms is quite different. In the IBDP textbook the numbers of later-defined terms are very high. For instance in the MEB textbook the terms autotroph and heterotrophs are defined at the beginning of cellular respiration topic, but in the IBDP textbook those terms are defined later, in the photosynthesis section.

Active participation of students

In the MEB textbook active participation of students is provided by daily life examples and thinking questions with real life connections (Table 10), research boxes, comparison activities and KWL charts (Table 20). In the IBDP textbook, examples for active participation of students are few and limited with only one question, one discussion and two TOK links.

Table 20

Activities of the two textbooks

MEB	IBDP
1. Research how energy which is found in the structure of ATP molecule, can be useable, how is this energy consumed in living things? (research box) 2. Which foods are used first for energy gaining? Search (research box) 3. What are other fermentations besides ethanol and lactic acid? 4. Why do leaves change colour in autumn? Do they photosynthesize when they are not green? Search and present (Research box) (p. 56) 5. KWL chart 6. Fermentation types 7. Comparison of aerobic respiration and fermentation 8. KWL chart 9. Photosynthesis and its reaction (making chloroplast model) 10. Comparison of photosynthesis and chemosynthesis	1. Different cultures use energy in different ways. Discuss the effects of energy shortages on both societies and individuals (p. 217). 2. Try writing an explanation as to why the rate would be altered as shown for each graph (factors affecting photosynthetic rate) (p. 235)

The names of the experiments in the MEB textbook and Heinemann website are shown in Table 21.

Table 21

Experiments for cellular respiration and photosynthesis

	MEB	IBDP
Experiments for cellular respiration	1. Cellular respiration in plant tissues (p.29) 2. Heat production during cellular respiration (p. 34) 3. Anaerobic respiration in yeast (p. 41) 4. Let's make yoghurt (p. 43)	1. Measuring the rate of respiration (in the Heinemann website within the topic 3)
Experiments for photosynthesis	1. Is CO_2 released during photosynthesis? (p. 55) 2. Diversity of pigments (p. 65) 3. Is CO_2 required for photosynthesis? (p. 72)	1. Paper chromatography method (in the Heinemann website within the topic 3)

Experiments in the MEB textbook can be considered as close-ended activities, as they give the purpose of the experiment and instructions step by step (Figure 10b). These kinds of experiments can also be called "cookbook labs" since they do not require writing a hypothesis and are based on following instructions without understanding.

Moreover, although there is no group study for experiments which have more steps and require more effort, students are directed to collaborate in making yoghurt and heat production during cellular respiration experiments which have fewer steps (Akkaya *et al*., 2011, p. 43).

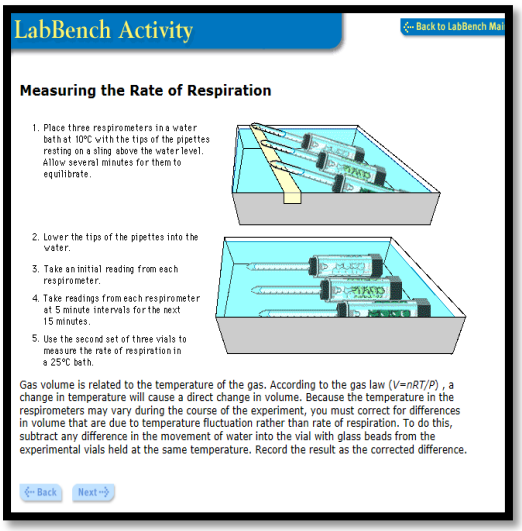
The IBDP textbook does not include any experiments or practical work in the textbook itself. There are two experiments in the Heinemann website both belonging to topic 3. The first experiment is about measuring the rate of oxygen by a respirometer. (LabBench, 2012). Students are directed to measure and compare the rate of respiration in germinating and non-germinating peas. In the website, students

are informed about the features and functions of a respirometer. Each step of the experiment is given clearly (Figure 10a). Students use their results to do calculations at the end of the experiment, thus their results do not rely merely on observation. However, similar to the MEB, in this experiment students are not required to write a hypothesis or to identify problems. Under the title of lab quiz, there are four multiple choice questions three of which are based on reading the graph. In the MEB textbook, there are questions after each experiment. Those questions are mostly thinking questions which make students think about different conditions for the experiment. Moreover, there are some "what if" questions which require reasoning/critical thinking (Akkaya *et al.*, p. 30).

In topic 3, there is another link to the Heinemann website. The link directs you to a second website, which gives a general overview of experimentation using paper chromatography (Paper Chromatography, 2012). However, the link does not provide any appropriate instructions of exactly how to perform an experiment. Moreover, it gives information about autoradiography which is not suitable for level and background of these students.

As topic 3 is part of the core syllabus (not advanced), and gives only an overview of photosynthesis with very few details, the level of the lab work seems too high, and inconsistent with the required theory.

(a)



(b)

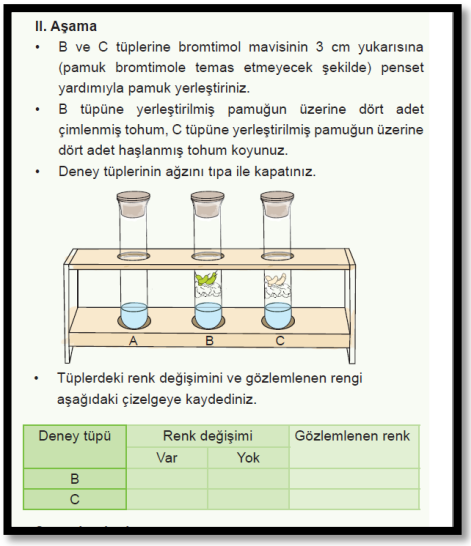
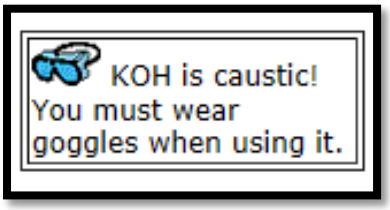


Figure 10. Sample pages of experiments from the IBDP web link and the MEB textbook (a) LabBench, 2012, (b) Akkaya *et al*., 2011, p. 30.

The presentation of the experiments in the MEB textbook and the Heinemann website are different in terms of technology. As seen in Figure 10, Heinemann website illustrates the steps of the experiment in more modern lab conditions. In the MEB textbook and in the Heinemann website, lab safety rules are shown as symbols (Figure 11).

(a)



(b)

Figure 11. Examples of lab safety rules from the IBDP web link and the MEB textbook (a) LabBench, 2012, (b) Akkaya *et al*., 2011, p. 29.

Targeted instructional and assessment strategies

In this section, the objectives of the two textbooks and their compatibility with assessment strategies were examined. To do so, the cognitive levels of objectives and

questions were determined according to Bloom's taxonomy and the data was double-checked by another researcher in order to ensure inter-rater reliability. Another reviewer (an MA student of educational sciences) was trained to conduct the analysis of a significant subset of material from the textbooks. After comparing results of the reviewer and the researcher, similarity above 95 % was regarded as an acceptable level of agreement for both objectives and questions. Any disagreements were resolved by further training.

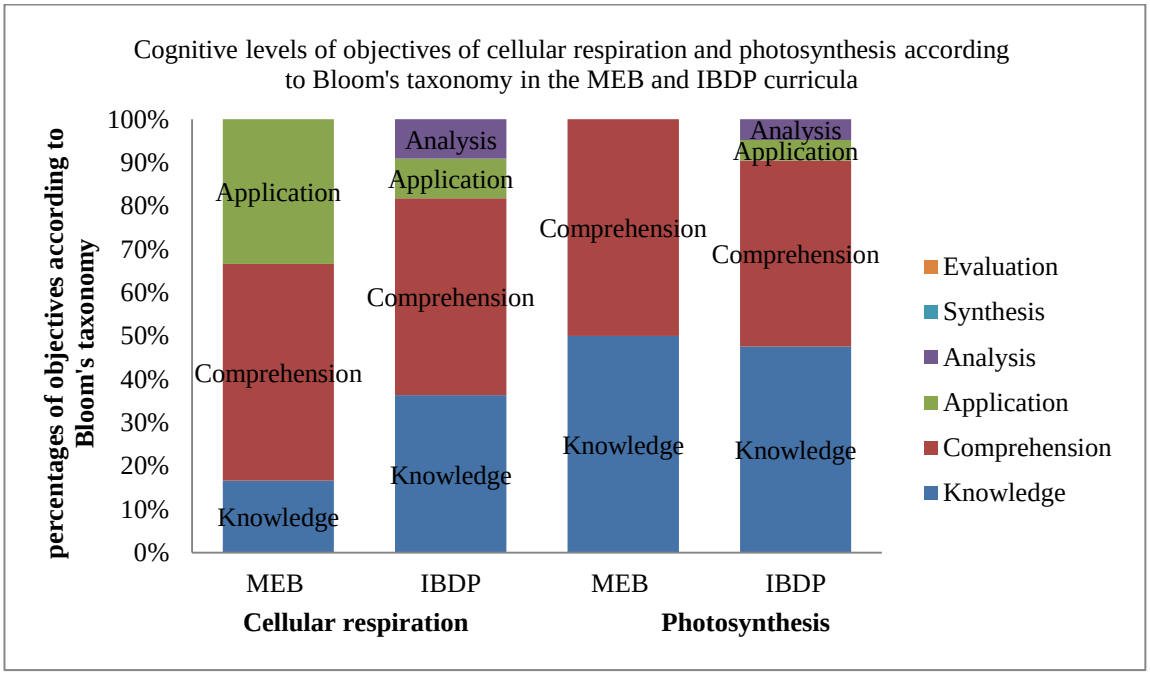


Figure 12. Cognitive levels of objectives of cellular respiration and photosynthesis according to Bloom's taxonomy in the MEB and IBDP curricula

The objectives of the two textbooks for both photosynthesis and respiration are mostly based on knowledge and comprehension levels which aim to recall specific pieces of information (Vosloo, 2004). In neither textbook, no objective aims to reach to the synthesis and evaluation levels which require higher-order thinking skills (Figure 12).

Assessment

The term assessment as used in this section refers to testing or other strategies that evaluate student progress as a result of learning activities. Such evaluation serves a dual purpose: (1) to assess an individual student's performance with regard to target learning outcomes, and (2) to provide information about the kinds of revisions needed to improve instruction.

Formative and summative assessment

Formative assessment which also refers to assessment for learning is defined by Keeley (2008) as "to inform the instruction and provide feedback to students on their learning" (p. 5). Summative assessment which also refers to assessment of learning aims "to measure and document the extent to which students have achieved a learning target" (Keeley, 2008, p. 5).

Table 22

Comparison of number of questions in the two textbooks

Types of questions	MEB textbook		IBDP textbook	
	Cellular respiration	Photosynthesis	Cellular respiration	Photosynthesis
In-text questions	12	17	1	1
After-experiment questions	20	15	4	-
Problems	6	2	-	-
Topic end questions	38	28	19	26
Total	76	62	24	27

In-text questions are mostly guiding questions which do not require a specific answer but make students think about the upcoming topic. The majority of in-text questions

in the MEB do not aim to assess students. In the IBDP textbook, there are very few in-text questions and those presented are also guiding questions. Problems are questions that mainly require calculations and are only seen in the MEB textbook. In the MEB textbook there are at least four after-experiment questions which are open-ended and which direct students to think about different conditions for the environment and possible results if conditions are changed. However, since the MEB textbook does not require writing any lab report, it depends on the teacher to use those questions for assessment.

Although there are some formative assessment strategies such as KWL charts and comparison tables and problems in the MEB textbook, in the two textbooks questions are mostly at the end of the unit (Table 22). Therefore, the two textbooks mostly focus on summative assessment rather than formative.

While comparing question types and Bloom's taxonomy of cognitive levels of questions of the two textbooks only topic-end questions are considered. The topic cellular respiration provides more questions than photosynthesis in the MEB textbook, but in the IBDP textbook photosynthesis has a higher number of questions than cellular respiration.

Question types are categorized as close-ended questions and open-ended questions. Whereas close-ended questions require low level cognitive responses and the text predetermines what the learner responds (Ellington & Race, 1985), open-ended questions may require higher order thinking skills, help learners to verbalise knowledge and make connections between what they see in their real life. There is one correct answer for close-ended questions and a single factual word or yes/no

answer is enough for answering those questions. However, open-ended questions have no predetermined boundary and students' answers may range freely over all options and permutations (Vosloo, 2004). In the two textbooks all questions are close-ended questions. Therefore, the assessment strategies of the two textbooks are limited to the recalling the knowledge. They do not give students an opportunity to expand their knowledge. To see many multiple choice and short answer questions is understandable and predictable for the MEB textbook because all questions in the university entrance exam (LYS-YGS) are multiple choice questions.

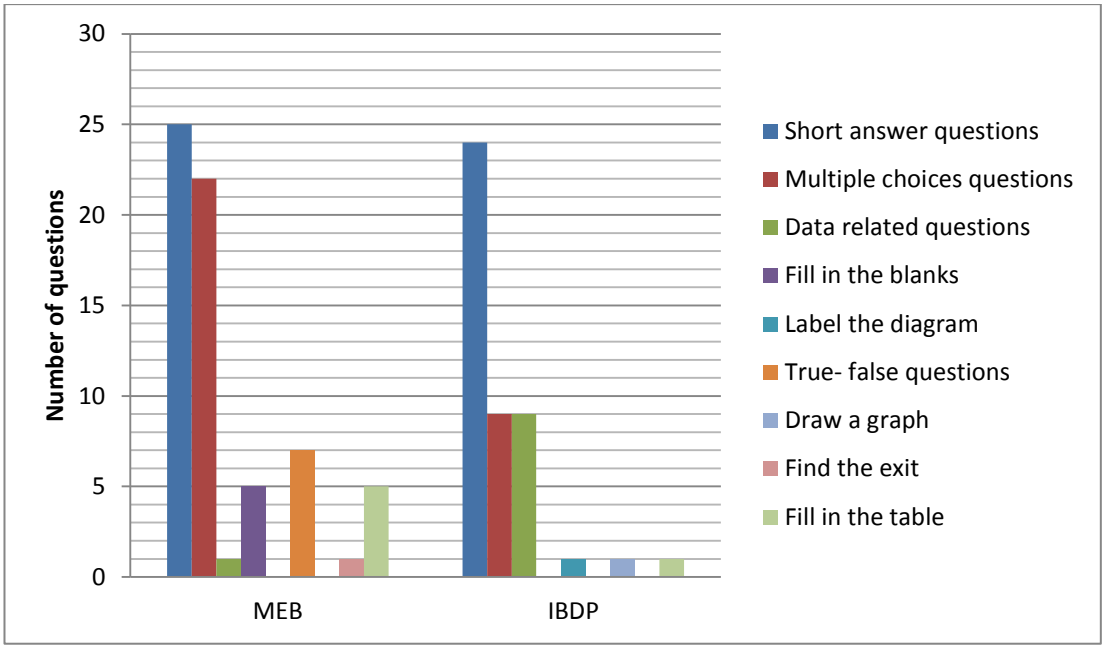


Figure 13. Question types in the MEB and IBDP textbooks

The cognitive levels of the questions were evaluated according to Bloom's taxonomy. Figure 14 shows percentage of levels of questions in the two textbooks.

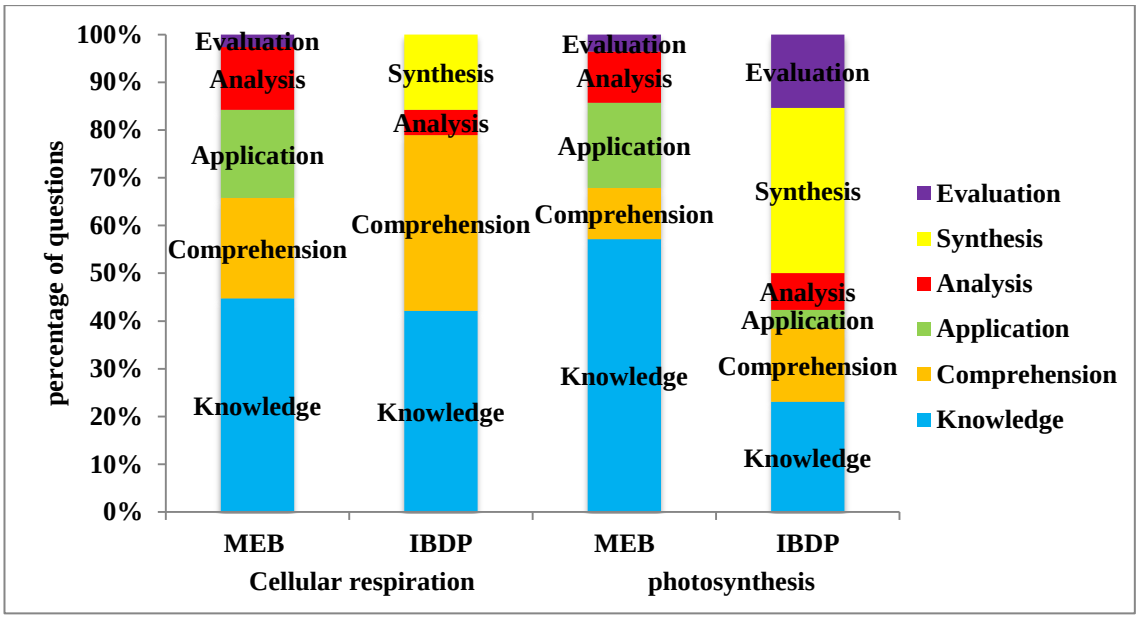


Figure 14. Cognitive levels of questions of cellular respiration and photosynthesis according to Bloom's taxonomy in the two textbooks

Since all of the questions are close-ended questions, the cognitive levels of the questions are mostly lower level (knowledge and comprehension) in the two textbooks. The questions are alike and mostly based on memorization. There are some ÖSS (former name of the university entrance exam in Turkey) questions in the MEB textbook. The number of data-related questions is very few in the two textbooks. There is no open-ended essay question which gives the opportunity to correlate previous knowledge or any daily life observation with the new knowledge in the two textbooks.

It is inferred that assessment strategies of the textbooks are mainly aligned with the objectives in terms of Bloom's taxonomy cognitive levels, since the majority of objectives and questions aim to measure knowledge and comprehension levels (Figures 12 and 14). Nevertheless, the cognitive levels of the questions in the IBDP textbook and the objectives of the IBDP do not fit because, although objectives do not aim to reach evaluation and synthesis levels, these levels of questions are dominant in the IBDP textbook for photosynthesis topic (Figures 12 and 14).

The distribution of cognitive levels of questions is irregular in both textbooks (Figure 14). The MEB textbook does not include any synthesis level questions for either cellular respiration or photosynthesis. The IBDP textbook has more varied level questions in the topic photosynthesis and the MEB textbook has more varied level questions in the topic cellular respiration.

Whereas there is an answer key for measurement and evaluation of Unit 1, there are no answer keys for topic-end assessment questions in the MEB textbook. Therefore, MEB students need to check their answers with their teachers. In the IBDP textbook, there are answer keys for both exercises and practice questions.

Opinions of practising teachers

The opinions of practising teacher about the content, presentation and learning strategies were obtained by semi-structured interview technique. Interviews were conducted one-by-one by using mostly open-ended questions (Appendix D). The opinions of practising teachers are vital because they are the ones who have to teach the curriculum and also prepare students for both the university entrance exam and the internal and external assessment of IBDP.

Interviews were conducted after completing the data analysis relating to this study. The interview questions were prepared by considering the compatibility of subcategories of the criteria.

Content

Practising teachers stated that the content of the MEB and IBDP textbooks is aligned with the curriculum requirements. The hours given for cellular respiration and photosynthesis are enough to cover all the content and do the practical work for the

MEB textbook. Moreover, teachers said that enough detail is given in the MEB textbook and it is adequate for doing well in university entrance exam. However, in the IBDP textbook especially topic 3 is very basic and is not sufficiently detailed. However, all IBDP teachers agreed that the IBDP is designed to be taught with a teacher; therefore it depends on the teacher to teach more or less.

Teachers indicated that the content of the IBDP textbook is not detailed enough. Since in the university entrance exam there are questions which require more detail to be solved, teachers need to use other sources. The content of the IBDP textbook is enough only for students who do not enter the university entrance exam but the information in the textbook needs to be supported by animations and worksheets.

Teachers clearly stated that they did not notice any misconceptions or inaccurate information in either textbook.

Whereas some of the practising teachers were happy about the place of cellular respiration and photosynthesis in the MEB curriculum, most of them stated that grade 10 is not appropriate to teach all of molecular levels of those topics because students may be discouraged by the difficulty of the topics and that may lead them to dislike biology. Since IBDP teachers do not need to follow the order in the book or in the curriculum, they prefer to teach photosynthesis and cellular respiration in grade 12 and they teach more interesting topics in grade 11 in order to increase motivation of students.

All practising teachers said that the order of subtopics is not appropriate in the two textbooks, but there was no consensus about their answers in terms of a preferred order. For example; some teachers thought that it is more logical to teach anaerobic respiration before aerobic respiration, some thought exactly the opposite.

Presentation

Teachers stated that page layout, readability and font size are appropriate for students' level for both the MEB and the IBDP textbook. IBDP teachers were also happy with the order of the IBDP textbook because it is written in the same order as the curriculum and they stated that this helps teachers to find where the topics are.

Teachers also stated that the linguistic style and tone of the textbooks are appropriate for students. According to teachers, the wording style of the MEB textbook encourages students' learning. The IBDP textbook is written in a conversational tone but there are not many real life connections, therefore it leaves a lot to teachers in order to make the topic more concrete. However, they also stated that in the IBDP textbook there are labelled summaries and comparison tables at the end of the topics, which strengthen students' knowledge. Some teachers also indicated that the MEB textbook has a lack of labelled summaries; labels should be added to the summaries. They also added that there should have been full comparison tables instead of empty comparison tables so that students may see the differences and similarities in one picture.

Teachers have positive ideas about the sizes of both textbooks but the weight of the IBDP textbook makes it less practical for using in the class.

Most teachers were happy about the visuals of both textbooks. The drawings illustrating oxidative phosphorylation were particularly considered to be helpful for students' understanding. However, some teachers stated that the MEB textbooks always have problems in the resolution of drawings- they are not clear enough.

Teachers said that the use of technology in the IBDP textbook is much better than that in the MEB textbook. They said they themselves use animations of Heinemann website in their lessons, but students barely or never visit websites of the textbook. They also mentioned that the MEB textbook is behind some technological developments.

Learning strategies

Teachers stated that in the IBDP textbook there are very few questions which are mixed in terms of cognitive levels. They also stated that although the number of questions is sufficient in the MEB textbook, their cognitive levels are not so high. They are mostly recall questions and with fever higher level questions.

They also added that the MEB textbook includes different forms of assessments compared to the IBDP textbook. Teachers were also pleased about the experiments in the MEB textbook, and their comments on the lack of experiments in the IBDP textbook were quite interesting: they stated that since students have to design an experiment as part of internal assessment, they should not find experiments in the textbook that they use. They also indicated that IBDP teachers are qualified biologists and they were capable of finding experiments themselves.

According to teachers, the two textbooks give clear explanations of many new scientific terms throughout the text. Teachers' comments on the lack of a glossary in the IBDP textbook were that "students never check the glossary".

Teachers' answers about pedagogical issues and motivational strategies of the IBDP textbook are quite varied. Whereas some teachers find the IBDP textbook sufficient in terms of pedagogy, the rest stated that it is written with the teacher in mind,

therefore it lacks some points in terms of pedagogy, but they also mentioned that it is the teacher's job to motivate students. Participants also mentioned that examiner hints throughout the text support students in terms of understanding more important topics. Teachers pointed out that the MEB textbook is good in terms of pedagogy since there are many real life connections, experiments and varied forms of activities.

Conclusion

In this chapter, the data collected from the MEB and IBDP biology textbooks and interviews were analysed and interpreted. The criteria used in the subcategories were briefly explained in each section, and evaluation and comparison were carried out by considering those categories. The qualitative research method was enriched by quantifying particular data and triangulation was held by interviews with practising teachers.

In chapter 5, the results will be further explained and the relationship between particular data and science education will be addressed. Results will be discussed in terms of the importance of each subcategory in science learning. Moreover, practising teachers' opinions and the findings of this research will be compared. Finally, implications for practice and for further studies and limitations will be mentioned.

CHAPTER 5: CONCLUSION

Introduction

This chapter discusses data obtained by evaluating and comparing the content, presentation style and learning strategies of the topics cellular respiration and photosynthesis in the current MEB biology textbook and the selected IBDP biology textbook. The second aim of this study was to learn the opinions of practising teachers who have used the textbooks in their classrooms. The data obtained from textbook analysis was triangulated with the opinions of practising teachers in order to confirm the validity of the evaluation results. In this research the answers to the following research questions were sought:

1. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *content* (alignment with curriculum requirements, levels of treatment, accuracy of content, and authenticity of content)?
2. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *presentation* (organization of instructional materials, readability of textbook and ease of use)?

3. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of *learning strategies* (motivational strategies, teaching a few "big" ideas, explicit instruction, guidance and support, active participation of students, targeted instructional and assessment strategies)?

4. What are the opinions of practising teachers-who use the IBDP and MEB biology textbooks in their classroom-about the content, presentation and learning strategies of the two textbooks?

Content analysis is basically a qualitative research method. However in this study the data was also quantified to allow particular features of the two textbooks to be compared quantitatively. An overview of the method used in this study is summarized in Table 23.

Table 23
Overview of the method of the study

	Process	Data source	Aim
Qualitative Research	Content analysis	IBDP biology textbook MEB grade 10 biology textbook	To present differences and similarities between the two textbooks in terms of content, presentation and learning strategies
	Semi-structured interviews	Teachers who have used the two textbooks	To verify the validity of the data

The purpose of this chapter is to discuss the findings, consider the conclusions, and make recommendations for future research in the field of biology textbook analysis.

Discussion of the findings

This section discusses the major findings and conclusions that have been obtained through the data collection process. The findings of the study are presented under three sub-headings (content, presentation and learning strategies), each to be considered for each research questions. The findings obtained from interviews are given and discussed under each sub-heading together with the data analysis.

Content

1. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of content (alignment with curriculum requirements, levels of treatment, accuracy of content, and authenticity of content)?

Alignment with the curriculum requirements

The objectives of the MEB and IBDP biology curricula about cellular respiration and photosynthesis are quite different from each other in terms of the cognitive domains of Bloom's taxonomy (discussed later under the learning strategies heading). Both textbooks aligned with the curriculum requirements in terms of objectives and assessment statements. Some objectives of cellular respiration and photosynthesis in the MEB curriculum, differently from IBDP, refer to doing experiments and correlating the given knowledge with real life (Tables 5 and 6). Nonetheless all of the learning outcomes found in the MEB and the IBDP curricula are properly covered in their textbooks.

The basic difference between the two curricula is the name that is given for objectives. Whereas the MEB curriculum uses the word "outcomes", the IBDP curriculum uses "assessment statements" and, in the exam, the exact assessment statements are used as questions. Therefore, the first inference is that the IBDP objectives and exam style are fully compatible with each other.

Level of treatment

Objectives cannot include every single subtopics or key words. However, to make the given knowledge more logical some subtopics need to be covered with relevant

background information. The two textbooks generally cover similar subtopics by giving a general overview and then giving more and more details about the subtopics. Both textbooks missed some important subtopics that are essential to learn cellular respiration and photosynthesis (Tables 7 and 8).

The IBDP textbook covers fewer subtopics as compared to the MEB textbook, which may cause problems in the logical sequences of subtopics. Inadequate background information can be considered as one of the main reasons for students' misconceptions. In that regard, the views of practising teachers are in line with the findings of the study: they clearly indicated that the content of the IBDP textbook must be enriched by worksheets and animations and, to achieve integrating the requirements of both curricula, they should cover more subtopics.

The structures of both textbooks are from general to more specific, which shows that the level of treatment is considered in both textbooks. However, whereas each subtopic in the MEB textbook starts with thinking questions that also have links to daily life examples, in the IBDP textbook topics directly start with information or knowledge. Hints and prompts are essential in the early stages of learning. Making connections with real life, questions that require reasoning and critical thinking and previews are some important hints that should be considered in the presentation of new topics (FLDOE, 2008). The MEB textbook follows this guideline and supports students' learning with questions and real life connections.

Although the MEB textbook covers nearly all subtopics, it still lacks some important information related to the nature of science. For example, the relationship between structure and function of the chloroplast is explained with unnecessary details such as the percentages of organic compounds found in the structure of the chloroplast

(Akkaya *et al*., 2011). However, the relationship between the folded structures of grana which increase surface area and thus absorb more sunlight is not explained (which is a core concept for biology) (Michigan University Department of Education, 2007). It suggests that in this instance at least, developing a deeper and more complete understanding of biology's major themes is disregarded in the MEB textbook.

Since IBDP teachers may change the order of topics, it is not possible to talk about the position of cellular respiration and photosynthesis in the curriculum. The only point that can be discussed is that these topics may be covered in grade 11 or grade 12 (either of them seems appropriate to do so). However, in the MEB context, these topics have to be covered at the beginning of grade 10, which is controversial in terms of motivating students as some teachers say it is too difficult to learn in this grade.

Similar to the results of previous studies (Akaydın & Soran, 1998; Çobanoğlu & Şahin, 2009), this study also shows that the MEB textbook includes encyclopaedic details which are not appropriate for grade 10. For example: the molecular structure of chlorophyll is explained in detail, and the scientific names of many bacteria are given in chemosynthesis, both of which seem more appropriate for a college level biology course rather than high school biology.

The ideas of some practising teachers about the placement of the topics in the MEB curriculum were aligned with the findings of this study. Many teachers indicated that cellular respiration and photosynthesis are not appropriate to teach in grade 10 since they include complex redox reactions and a multitude of details.

Accuracy of content

The number of errors detected in the two textbooks is similar for each (Table 9). The most detected inaccuracies in both textbooks were based on inconsistencies between visuals and texts and within the text itself. Since the correct terminology affects accuracy of content, presenting the knowledge in a scientific way has an effect on the accuracy of content. According to the findings, the most important difference between the two textbooks is that the IBDP textbook presents the knowledge (especially in figures) in a more scientific way than the MEB textbook.

Previous research by Dikmenli, Çardak and Öztaş (2009) on the MEB science textbook showed that the topic photosynthesis had contained many scientific errors and inaccuracies. Dikmenli, Çardak and Öztaş (2009) pointed out that it was stated that chlorophyll is found only in green plants, and there were some misleading statements such as "respiration is the use of oxygen in the body" (p. 432). However, in the current MEB biology textbook, the first example was corrected and now states: "chlorophyll is found not only in green plants but also in some photosynthetic bacteria" (Akkaya *et al.,* 2011, p. 59). Also cellular respiration and breathing are clearly distinguished as "the word 'respiration' cannot be used for the activity that moves air in and out of the lungs, the word 'breathing' must be used for this activity" (Akkaya *et al*., 2009, p. 22). Comparing previous research on the MEB biology textbooks with this study, it can be concluded that the MEB textbook has made progress in terms of the accuracy of its content.

Authenticity of content

Real life connections

Examples from everyday life are considered to be a positive aspect for a science textbook. Applications and examples from daily life improve the quality of the didactic approach of the textbook (Pop-pacurar & Ciascai, 2010). Relating science to daily life is one of the most important criteria and is a sign of pedagogical appropriateness of a textbook (Swanepoel, 2010).

Real life connections affect the breadth and depth of topics by presenting ideas or information that are common or familiar to students or that they experience outside school. The MEB textbook has more life connections for both cellular respiration and photosynthesis than the IBDP textbook. Therefore, in terms of life connections, the MEB textbook is more student-friendly and gains an extra point in terms of didactical aspects.

In the IBDP textbook, the absence of connections with everyday life can be considered as a lacking point because the textbook does not give students opportunity to relate what they experience in daily life to their science lessons.

Interdisciplinary treatment

When textbooks present information in an interdisciplinary manner, with explanations and practice activities for transferring skills and knowledge from one subject area to another, they improve learning (FLDOE, 2008). In that regard the MEB textbook supports students' learning since it includes many more links to other disciplines (such as mathematics, chemistry, physics and history) than the IBDP textbook.

Presentation

2. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of presentation (organization of instructional materials, readability of textbook and ease of use)?

Organization

The analysis of the two topics with respect to general organisation showed that the MEB textbook allocates a large number of pages for the topic explanations as well as for the assessment (Table 11). One of the reasons is that in the MEB curriculum, time allocated for covering these topics is nearly twice more than the IBDP textbook. It therefore seems reasonable to have more pages for both explanation and assessment in the MEB textbook. The other reason is that the linguistic style and tone of the MEB textbook, which is more likely to tell a story, is different from the IBDP textbook. Further, the MEB textbook contains more subtopics such as ATP, C_3, C_4 and CAM plants (Tables 7 and 8), student-centred activities (Table 20), and experiments (Table 21).

The analysis of the typographical features (format, design and layout) of the two textbooks showed that both are attractive in terms of design and layout and have student-friendly typographical features (Figure 7). In both textbooks, the text was enriched by visuals, drawings, graphs and photographs. One of the most prominent differences between the two textbooks is that the MEB textbook has many more visuals for photosynthesis than the IBDP textbook (47 for the MEB textbook/24 for the IBDP textbook, see Table 16).

"Effective instructional materials generally integrate using reference aids such as index, glossary, maps, bibliography, graphic organizers, and pictures" (FLDOE, 2008, p. 37). The MEB textbook has a glossary in which students can find every single new scientific term that is mentioned in the text. Glossary is a very useful aid especially for a subject like biology which includes many scientific terms. The IBDP textbook however includes neither a glossary nor a bibliography, which renders it less useful to both students and teachers.

Readability

Textbooks should be written fluently in language which can be easily understood by students and which should ensure systematic improvement in learning of both knowledge and concepts (Ajewole, 1991; Shymansky, Yore & Good, 1991). Kaptan (1999) claims that textbooks should be adequate in terms of combination and comprehensibility features: combination, namely establishing connection, improves the ability of students to understand a written source. Dikmenli (2010) adds that clear short sentences can be much more easily comprehended by students than complex ones.

The readability scores of the two textbooks are almost the same (48.6 and 48.1) but neither is appropriate for the age level (Appendix A). However, in this study readability was not measured only by readability formulae; language tone and style were also considered. The language style of the MEB textbook was found less monotonous and less technical as compared to the IBDP textbook. The IBDP textbook was written in an impersonal tone which ignores students' needs. This is in line with what Ulerick (2012) concluded about the language of textbooks: "textbook authors write as if the reader has as much prior knowledge as they do; and they

assume that readers are familiar with the style and structure of expository writing" (p. 2). In that regard it seems that the IBDP textbook fails to present clear content that serves students' understanding.

Typographical features and readability have a great role in helping students to learn science from a textbook. A biology textbook includes many new scientific terms, and textbook authors must be careful about language tone and style.

Ease of use

The durability of the IBDP textbook seems to be weaker than the MEB textbook since it has 706 pages which make it heavy and difficult to carry, and pages split away easily. Moreover, the high cost of the IBDP textbook (115 TL) can cause problems in terms of affordability.

Learning strategies

3. How are cellular respiration and photosynthesis covered in one IBDP and one MEB biology textbook and the related sections of each curriculum in terms of learning strategies (motivational strategies, teaching a few "big" ideas, explicit instruction, guidance and support, active participation of students, targeted instructional and assessment strategies)?

Motivational strategies

The language of the textbooks was again considered in this section since language has a role in motivating students and, as stated earlier, the MEB textbook increases students' motivation by using a non-monotonous word style.

Student-centred activities and other tasks which offer active participation to students are rarely found in the IBDP textbook, but are frequently seen in the MEB textbook. As seen in Tables 20 and 21, the MEB textbook has a variety of activities and some experiments which require group study. In that regard, in comparison to the IBDP textbook, the MEB textbook is better in terms of motivational strategies. However, as seen in Table 3, motivational strategies cannot be restricted only to the presence and variety of activities, there should also be thought-provoking challenges that are not too easy or not too difficult. In this respect, the presentation and requirements of experiments can be considered as insufficient since they are all cook-book labs. However, after-experiment questions are challenging. To sum up, although the MEB textbook has some problems in terms of motivational strategies, it is still far more effective than the IBDP textbook.

Technology is very important in today's classrooms. It is almost impossible to satisfy today's children without using any technological aid. Moreover, in biology teaching, animations, models, and computer simulations are widely used all around the world. Those aids are very useful and it is stated that they improve students' learning and increase motivation (Yager & Akçay, 2008; Lai, 2011). They are particularly important for visual learners. The IBDP textbook seems to give importance to technology, whereas the MEB textbook did not consider technology at all. The attractive design of the Heinemann website and animations are also important to increase students' motivation. It is a pity not to see any technology or web-link in the MEB textbook.

Teaching a few big ideas

Textbooks must provide multiple and varied ways to support the key ideas or major themes (American Association for the Advancement of Science [AAAS], 2002). Ornstein (1992) stated the importance of core concepts which "help students to organize what they are learning, follow the sequence of learning, and make sense of the information, facts and concepts" (p. 167).

National Science Education Standards (1996) stated that major themes have a great role in unifying concepts and processes in science and presenting science as inquiry. In that regard, since the IBDP textbook includes more major themes such as specialization of cells to carry out particular life functions, it helps students to develop deeper and more complete understanding of the nature of science (FLDOE, 2008).

Explicit instruction

The clarity of textbooks is important since explicit instruction communication of the skills to be learned helps to improve thinking skills (FLDOE, 2008). Learning improves with clear objectives and interactions focused on specific problem solving and explicit teaching of thinking skills (Bonwell & Eison, 1991; Kassem, 2006). Both textbooks have clear instructions, and efficient transitions on what is about to finish and what is coming next, together with directions on how to preview, answer, read and use the textbooks.

Guidance and support

"Guidance and support most often comes from a good teacher but instructional material can also support" (FLDOE, 2008, p. 56). Okebukola and Owolabi (2008)

concluded that "comprehension of science depends on the effective integration of appropriate ways of thinking, use of language and the appropriate degree of scaffolding to support students' attainment of intended intellectual outcomes" (p. 147). Without using methods that serve to improve skills that correlate the unknown with the known, we cannot talk about effective guidance and support.

Analogies are important communication tools that support science learning as they "introduce an unfamiliar idea by sharing some similarities to a familiar idea" (Okebukola & Owolabi, 2008, p. 147). Since the MEB textbook includes more analogies than the IBDP textbook (Table 18), it has better communication strategies in terms of analogies.

Another important issue for evaluating guidance and support is the number and presentation of scientific terms. Groves (1995) stated that one of the reasons for reliance on textbooks in a science course is because they have a heavy focus on science vocabulary (Groves, 1995). Heavy use of scientific terminology can be an obstacle to reading comprehension since the readability levels of many science textbooks are often higher than the grade levels for which they are targeted (Wrights, 1982).

While immediately-defined terms promote easier reading and comprehension, undefined or later defined terms are likely to impede the students' understanding or discourage him/her from reading the text further (Soyibo, 1996). Immediately-defined terms are therefore desirable. In this respect, the MEB textbook supports students' learning more than the IBDP textbook, since the percentages of immediately-defined terms are higher in the MEB textbook (Figure 9).

Active participation of students

As Shannon (1999) pointed out "the concept of opportunity to learn is linked to the concept of opportunity to perform" (p. 55). As stated earlier, the MEB textbook offers a greater number of student-centred activities and practicals, in other words, more opportunities to perform, therefore it gives more opportunities to learn (Tables 20 and 21).

However, in the MEB textbook the purpose of the experiments is stated at the beginning of the experiment which takes away the curiosity of students, and thus prevents scientific inquiry. To promote students' learning students should be given the opportunity to create their own hypothesis. Moreover, in the MEB textbook there is an inverse relationship between the difficulty level of the experiments and group studies. For example: there is no group study for experiments which have more steps and require more effort such as cellular respiration in plant tissues, students are directed to collaborate only in doing the yoghurt experiment and heat production during cellular respiration (Akkaya *et al*., 2011, p. 43). Students should have been directed to work collaboratively in other experiments as well.

Targeted instructional and assessment strategies

Since varied forms of assessment increase students' motivation, using different types of assessment and different types of questions are important. As claimed by Lowery and Leonard (1978) questions act as stimuli to inquiry. Ulerick (2012) supported that by stating that textbook questions create a purpose for reading. It can be concluded that the more questions in a textbook, then the better opportunity for readers to stimulate their curiosity. In this respect, the MEB textbook gives better opportunities to feed curiosity of students than does the IBDP textbook.

The results of this research showed that the MEB textbook provided more questions than the IBDP textbook (Table 22). Since questions have an important role in developing the cognitive skills of the students, they must include questions that require higher order thinking skills. For cellular respiration the MEB textbook includes more questions that assess higher order thinking skills, whereas for photosynthesis the IBDP textbook includes more questions that assess higher order thinking skills (Figure 14). However, in general we can say that both textbooks focus on the recall of knowledge, thus giving less emphasis to the development of higher level cognitive thinking in students (Hummel & Huit, 1994).

Since the Turkish exams, YGS and LYS, are standardized tests that contain only multiple-choice items (as sole source of information) (NRC, 1990), the majority of questions found in the MEB textbook are multiple choice questions where students are asked to recognize the best choice among four or five possible answers. Such tests are limited in determining achievement in that they measure, by recognition, only a small sample of factual information (NRC, 1990). These kinds of questions rely on the recall of information and do not reflect the conceptual nature of biology. Thus, they reduce and distort testing for concepts by testing mainly for words and definitions instead (NRC, 1990).

As pointed out by Kerry (1986) open-ended questions encourage students to apply, analyse, synthesise and evaluate. In that regard, it seems that both textbooks fail to stimulate higher-order thinking skills.

Conclusion

To conclude, both textbooks have different characteristics in terms of content, presentation and learning strategies.

The findings discussed above, by considering the features of effective science textbooks, have shown that each textbook has strengths and weaknesses which make them more or less effective for students' learning. As the MEB and the IBDP curricula have different requirements and characteristics, the textbooks which reflect them necessarily have different features, even if they present the same topics.

The findings related to the content of the two textbooks showed that the MEB textbook is more effective than the IBDP textbook in terms of real life connections and interdisciplinary treatment. But the too detailed information given on the topics makes the MEB textbook less appropriate for the students' level (grade 10).

Considering the presentation of the textbooks, it was concluded that the MEB textbook is more student-friendly with respect to organisation and ease of use, but both textbooks have similar features in terms of readability.

The effectiveness of the MEB textbook with regard to learning strategies is better in terms of motivational strategies, explicit instructions, guidance and support, active participation of students and targeted assessment strategies.

Overall, the MEB textbook is a useful resource for teachers since it includes more activities, experiments and different types of assessment tools that they can use in their lessons. Since the IBDP textbook includes fewer activities and assessment tools, IBDP teachers need to provide worksheets, experiments, and activities to supplement the teaching and learning.

Implications for practice

Textbooks are the main instructional materials for learning and teaching science in the science classroom. Therefore, textbook selection must be done carefully by

people who have responsibility in the field of education. Of course, teachers are the most important people who use textbooks in their classrooms and they should be aware of the weak and strong points of the material they use.

As can be concluded from the findings of this study, there are many important components that make a textbook high-quality. A biology textbook must include a variety of student-centred activities, relative visuals, real life examples, and varied forms of assessment strategies in order to motivate students. Moreover, the language of the textbook must be appropriate for the students' level and new scientific terms must be defined immediately or before they are used in the text.

It seems that the job of textbook writers is not easy. Of course, textbook authors must be experts in their subject areas but in the writing committee, there must be people who are experts in pedagogy as well as subject area teachers. Since readers of biology textbooks are high school students, didactical aspects must be taken into account.

This study also implies that many features can be evaluated by well-developed criteria which consider every aspect of content, presentation and learning strategies. Therefore, in the textbook selection process, well-developed criteria must be used and textbooks must be evaluated from the perspective of both students and teachers.

Moreover, since the ideas and recommendations of classroom teachers and students are very important, textbooks may be pilot-tested or implemented in some classrooms. In the light of the feedback received, the textbook may be improved.

In addition to the above, results of textbook analysis and evaluation studies must also be taken into account while writing in order to publish a high-quality textbook.

Implications for further research

The interviewee number in this study was limited to five biology teachers. As teachers are the ones that use textbooks in their classrooms, their expectations and opinions are important in order to evaluate quality of textbooks. Therefore, the ideas and expectations of more biology teachers from different schools would have given a broader perspective to the study.

More textbooks would have given more data about the different textbooks. However, there is only one MEB biology textbook that is approved by MEB. In further research, more IBDP textbooks could be analysed and compared to the MEB biology textbook.

To analyse more topics from different textbooks would give more reliable data about content, presentation and learning strategies of the textbooks and educational programs since different topics have different characteristics, importance and requirements in the context of different programs.

The opinions of students are as important as those of teachers in textbook evaluation. Therefore evaluating and comparing the textbooks from students' perspectives, including their needs and expectations to improve learning would have given the study a broader perspective about the use and usefulness of textbooks in schools.

Limitations

One of the limitations of this study is that only two topics were chosen as the representative content to be analysed. In the MEB biology curriculum, cellular respiration and photosynthesis are covered in grade 10, and there is only one grade 10 biology textbook approved by MEB. This study is therefore limited to only one

grade 10 MEB biology textbook, and -as a comparison- from several possible IBDP biology textbooks, in this study only one IBDP textbook was analysed.

The number of participants was another limitation for this study. Only five biology teachers, three of whom were also academics, participated in this study.

Another limitation of this study was that some teachers do not see the textbook as the main instructional material to be used in the class. They state that teachers have the responsibility to teach the topic, not the textbook, which they supplement with their own material. They therefore ignore any lack of important features in the textbook. However, textbooks need to be written by considering pedagogical features at least for some students who may suffer from learning in the class or enjoy self-study.

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APPENDIX A

Flesch readability score classification table

Readability Number Readability Levels
90–100 Very easy
70–89 Easy
50–69 Medium difficult
30–49 Difficult
1–29 Very difficult

(Ateşman, 1997, p. 71)

APPENDIX B

Paragraphs from the IBDP textbook

Embedded in the involved membranes are molecules that are easily reduced and oxidized. These carriers of electrons (energy) are close together and pass the electrons from one to another due to an energy gradient. Each carrier molecule has a slightly different electronegativity and, therefore, a different attraction for electrons. Most of these carriers are proteins with haem groups and are referred to as cytochromes. One carrier is not a protein and is called coenzyme Q. In this chain, electrons pass from one carrier to another because the receiving molecule has a higher electronegativity and, therefore, a stronger attraction for electrons. In this process of electron transport, small amounts of energy are released (p. 396).

The various pigments of photosynthesis absorb photons of light from specific wavelengths of visible spectrum. If white light, which contains all the wavelengths of the visible light spectrum, is passed through the chloroplast of a plant cell, not all wavelengths are absorbed equally. This is because of the specific pigments present in the chloroplasts of that particular type of plant. A device called spectrophotometer can be used to measure absorption at various wavelengths. This results in a characteristic absorption spectrum for the plant. The absorption spectrum of a plant is the combination of all the absorption spectra of all the pigments in its chloroplasts (p. 406).

Once the two G3P molecules are formed, they enter an oxidation phase involving ATP formation and production of the reduced coenzyme NAD (see figure 14.11).

Each G3P or triose phosphate molecule undergoes oxidation to form a reduced molecule of NAD+, which is NADH. As NADH is being formed, released energy is used to add an inorganic phosphate to the remaining 3-carbon compound. This results in a compound with two phosphate groups. Enzymes then remove the phosphate groups so they can be added to ADP to produce ATP. The end result is the formation of four molecules of ATP, two molecules of NADH, and two molecules of pyruvate (p. 393).

Organic molecules contain energy in their molecular structures. Each covalent bond in a glucose, amino acid or fatty acid represents stored chemical energy. When we burn wood in a fire, we are releasing that stored chemical energy in the form of heat and light. Burning is the release of chemical energy called rapid oxidation. Rapid oxidation is not controlled by enzymes and results in the breaking of many, many covalent bonds in a very short period of time and thus a nearly uncontrolled energy release. Cells break down (or metabolize) their organic nutrients by way of slow oxidation. A molecule, such as glucose, is acted on by a series of enzymes (p. 70).

The limiting factor has its effect and the others do not because of the complexity of the process. Photosynthesis has many steps that lead to the end-products. When one step is slowed by the limiting factor, the whole process is slowed. This particular step would be called the rate-limiting step. Figures 14.27, 14.28 and 14.29 show light, carbon dioxide and temperature in their roles as limiting factors. In each graph, photosynthetic rate is shown on the *y* axis. These graphs are obtained by altering only one variable at a time. This means we can draw a definite conclusion as to the cause of the change in photosynthetic rate (p. 408).

APPENDIX C

Paragraphs from the MEB textbook

Sporcular ağır egzersiz yapmaya hazırlanırken pilav, patates ya da karbonhidrat bakımından zengin diğer besinleri yiyerek hücrelerine karbonhidrat yüklemesi yapar. Aynı şekilde bitkiler de tohumlarında nişasta ve yağ depolar. Böylece tohumda çimlenme ve gelişme hızlı bir şekilde başlatılabilir. Sporcunun ya da bitki embriyosunun hücrelerinde organik bileşiklerin yıkımını sağlayan kimyasal tepkimeler enerjiyi açığa çıkarır (p. 19).

Organik besinlerin oksijen kullanılmadan, enzimler yardımıyla daha küçük moleküllere parçalanması sonucu açığa çıkan enerjiyle ATP sentezlenmesine oksijensiz solunum (fermantasyon) denir. Mayalanma olarak da bilinen fermantasyon işlemi bir maddenin bakteriler, mantarlar ve diğer organizmalar aracılığıyla genellikle ısı vererek ve köpürerek kimyasal parçalanma olayıdır. Oksijensiz yolla enerji elde edilmesi bakterilerin büyük bir bölümünde, maya mantarlarında, omurgalıların çizgili kaslarında ve bazı tohumlarda gerçekleşir. Fransız kimyager Louis Pasteur (Lui Pastör) 1857'de fermantasyonu canlı maya hücrelerinde izleyerek keşfetmiştir. Pasteur, fermantasyon üzerine yaptığı çalışmaların sonucuna göre kendi adı ile anılan pastörizasyonun esaslarını ortaya koymuştur. Bira veya şarapta meydana gelen her değişimin bunları fermente eden veya bozan mikroorganizmalardan kaynaklandığını biliyordu (p. 38).

Cisimleri neden farklı renklerde görürüz? Çevrenizde gördüğünüz otsu bitkiler, ağaçların yaprakları, dalları ve olgunlaşmamış meyveler niçin yeşildir? Bu soruları

zaman zaman merak etmişizdir. Işık bir cisme çarptığında cisim tarafından yansıtılabilir, emilebilir ya da cismin içinden geçebilir. Bu üç olay aynı anda da olabilir. Görünür ışığı emen maddeler pigment olarak isimlendirilir. Farklı pigmentler, farklı dalga boyundaki ışığı soğurur, soğurulmayan ışınları ise geçirir ya da yansıtır. Eğer bir pigmente beyaz ışık gönderilirse pigment tarafından yansıtılan ya da geçirilen ışık gözümüzün seçebileceği rengi oluşturarak cisimleri farklı renklerde görmemizi sağlar. Örneğin kloroplastlarda bulunan pigmentler mavi ve kırmızı ışığı soğururken yeşil ışığı geçirir ya da yansıtır (p. 62).

APPENDIX D

Interview questions

Content	1. How well does the textbook align with the curriculum requirements? 2. How accurately is the content presented? Did you find any inaccuracies and misconceptions? If so, what are they? 3. Is the textbook by itself enough to teach the topic effectively? Explain why. 4. What do you think about the place of cellular respiration and photosynthesis in the textbook? 5. How well is the content organized in terms of order of subtopics?
Presentation	1. What do you think about the typography (the style and appearance of textbook) of the textbook? 2. What do you think about the linguistic style and tone of the textbook? 3. What do you think about the visuals of the textbook? Are visuals compatible with the texts? Explain. 4. How well does the textbook benefit from technology?
Learning	1. How well do the experiments support students' learning? 2. Are there different forms of assessment? 3. How well are the new scientific terms explained? 4. Are there tasks related to student interests, and activities relevant to the student's life? 5. What do you say about the cognitive levels of questions according to the Bloom's taxonomy? How well do questions assess students' learning? 6. If a student missed class, could (the student) reasonably be expected to learn the missed material by reading the book or by completing the computer program or other media activities?